FY2014 Decontamination Report

- A compilation of experiences to date on decontamination for the living environment conducted by the Ministry of the Environment -

(Tentative Translation)

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Ministry of the Environment

Tentative Translation

< Attention >

This material was translated temporarily and might be corrected in the future.

Introduction

Radioactive materials were released by the accident at the Fukushima Daiichi Nuclear Power Station (1FNPS) after being hit by the Great East Japan Earthquake and ensuing Tsunami on March 11, 2011. The Government of Japan as well as prefectural and municipal governments have been taking measures to decontaminate the contaminated soil and wastes (hereinafter referred to as “decontamination”), in order to reduce the impact of radioactive materials on human health and the living environment as soon as possible.

In the efforts for the decontamination, all available resources including those from the central and local government offices, research institutions, and private cleaning operators have been put together, along with the most recent scientific and technical knowledge available from Japan and abroad. Of course it is the most important for the world never to repeat such a disaster in the future. In the meantime, disclosing and sharing our knowledge, experiences, and lessons obtained through the decontamination efforts at this time with domestic peers and the international community will be significant to accelerate the decontamination work in Japan and minimize the potential damage in future accidents in the world for the implementation of expeditious and efficient decontamination.

Therefore, in this Decontamination Report (hereinafter referred to as “the report”), the Ministry of the Environment (MOE) has comprehensively compiled the basic policy of the decontamination and implementation framework, knowledge about the management of decontamination projects based on the actual decontamination operations on-site, together with the procedures, conditions and effects of individual decontamination techniques, by mainly focusing on the decontamination operations performed by the MOE. Thus, this report is deemed to be a fundamental document to disseminate both domestically and internationally our experiences, lessons and knowledge learned through the decontamination efforts.

The report consists of the following seven chapters:

1. Basic features of the environmental decontamination in Japan
2. Overview of decontamination methods
3. Management and treatment of decontamination wastes
4. Management of decontamination projects
5. Effects of decontamination
6. Overview, usage and conditions of decontamination technologies and verification of their effects
7. Conclusion

Chapter 1 describes the history and background of the demonstration projects, the contamination status of decontaminated areas and features of the demonstration projects. Chapter 2 outlines the process to establish decontamination procedures and decontamination methods on the basis of the MOE’s document “Decontamination Guidelines (2nd Ed., 2013)” Chapter 3 explains the management and treatment of removed soil and wastes derived from decontamination works with examples of temporary storage sites, disposal and treatment of water used for decontamination works and volume reduction for burnable wastes. Chapter 4 illustrates operation planning for a large range of decontamination projects, including such example tasks as acquiring stakeholders’ consent, having effective communication with residents, managing the projects and providing radiation protection, education and health care for decontamination workers. Chapter 5 presents a wide range of area-wide decontamination effects and their evaluation approach. Chapter 6 explains decontamination methods and their effects from a technical viewpoint on the basis of data obtained in test decontamination works in order to demonstrate findings on the effects of individual decontamination technologies used in the full-scale decontamination works. Chapter 7 summarizes the main points of the report.

It is the expectation of the MOE that this report will facilitate more effective and efficient decontamination works in the environmental remediation after the accident at the 1FNPS, and contributes to preparations for potential nuclear accidents and related research worldwide.

Contents

1. Basic features of the environmental decontamination in Japan

The decontamination projects associated with the accident at the Fukushima Daiichi Nuclear Power Station (1FNPS) of Tokyo Electric Power Co., Inc. (TEPCO) have the following basic features involving the status of environmental pollution, geographical factors, and the stance of the national and the local governments toward residents.

- The principal radionuclide causing environmental pollution is cesium.
- Decontamination should be conducted to reduce the impact on human health or the living environment not only in housing areas and public facilities, but also in diverse and wide areas including roads, farmlands, forests around the living space, and the like.
- Decontamination should be implemented as soon as possible for early return, safety protection and life rebuilding of residents in the evacuated areas.
- Residents' opinions and their way of life should be respected; decontamination should be conducted by paying due consideration to the protection of private rights and maintenance of the community.

Hereinafter, the history and the background of decontamination, the status of the radioactive contamination, and features of decontamination works are given in the following parts 1.1, 1.2 and 1.3, respectively, which led to the formation of the above characteristics.

1.1. History of the environmental decontamination

1.1.1. Specific features of the decontamination in Japan and Fukushima Prefecture

In Japan, about two-thirds of the country is occupied by forests, and the proportion of the inhabitable land areas limited to about the remaining one-third. Therefore, the population density in inhabitable land tends to be high. In addition, as Japan is the only nation to have been hit by nuclear bombs, the Japanese people have a stronger interest and greater concern than the people of other countries toward the damage caused by radiation. On the other hand, knowledge about radiation and its influence on the human health had not been shared sufficiently among ordinary person, before the Great East Japan Earthquake.

In Fukushima Prefecture, which most strongly received the effects of the nuclear power plant accident, the population in October 2010 was about 2 million people and the total area is approximately 14,000 square kilometers. While this is a vast land area, it is used in various forms. The utilization ratio of the land[1] is: forests, about 70 %; agricultural land, about 11%; the surface covered with water bodies, rivers and waterways, about 3 %; and roads and residential land, about 4%. The east side of Fukushima Prefecture faces the Pacific Ocean, and the west side is surrounded by mountains. Therefore the situation of the four seasons is quite different between in the eastern and western regions of the prefecture. In 2014, Fukushima City, located in the central region, had 96 snowfall days and the number of days was relatively large in Japan. Based on these specific circumstances in Japan and Fukushima Prefecture, most appropriate decontamination activities are due to be carried out.

1.1.2. History of the principal events associated with decontamination

(1) Occurrence of the accident at the nuclear power station and evacuation of residents

At 14:46 on March 11, 2011 (Japan time, hereinafter all times are this), an earthquake occurred off the Pacific Coast of northeast Japan. The earthquake and ensuing tsunami damaged facilities of the Fukushima Daiichi Nuclear Power Station (1FNPS) and the Fukushima Daini Nuclear Power Station (2FNPS) of Tokyo Electric Power Co., Inc. (TEPCO), setting the stage for an unprecedented complex nuclear accident that led to releases of substantial amounts of radioactive materials to the atmosphere from the 1FNPS.

[1] Source: Fukushima Prefecture, "2014 edition, Recording of the main data in Fukushima Prefecture" (http://www.pref.fukushima.lg.jp/sec/11045b/26youran.html)

Then Prime Minister Naoto Kan declared a nuclear emergency situation at 19:03 on March 11, 2011, and established the Nuclear Emergency Response Headquarters (NERH) within the Prime Minister's Office according to the Act on Special Measures Concerning Nuclear Emergency Preparedness (Law No. 156, 1999).

In the meantime, the Fukushima Prefectural Government set up the prefectural headquarters for disaster control. Upon receipt of the declaration of a nuclear emergency situation at the 1FNPS, at 20:50 on March 11, 2011, the Governor of Fukushima ordered Okuma and Futaba Towns to evacuate the residents living within the radius of 2 km from the 1FNPS.

At 21:23 on March 11, 2011, the NERH ordered the Fukushima Governor and other relevant authorities of the municipalities to evacuate the residents living within the radius of 3 km from the 1FNPS and to order those living within the radius of 10 km from the 1FNPS to remain indoors. Then, on March 12, 2011, the NERH ordered the Fukushima Governor and other relevant municipalities to evacuate all residents living within the radius of 20 km from the 1FNPS.

Later, following the hydrogen explosion at Unit 3 and others on March 14, the NERH on March 15, 2011, ordered the Fukushima Governor and relevant authorities of the municipalities to instruct the residents living in an area between the radius of 20 km and 30 km from the 1FNPS to remain indoors.

On March 17, 2011, the Ministry of Health, Labour and Welfare (MHLW) set the index values[2] on food and drink intake limit of radioactive materials as provisional regulation values of the Food Sanitation Act, and began the radioactivity monitoring of foods[3].

On March 19, 2011, radioactivity exceeding the provisional regulation values of radioactive materials in foods were detected in certain areas in spinach and raw milk, etc., and in response to this situation, the NERH summarized a "Monitoring plan, and a policy on setting and lifting of the food items and the areas to be subjected to shipment restrictions, etc.". In addition, concerning the planting of rice which is a staple grain food in the Japanese diet, the NERH presented on April 8, 2011, "The policy on planting of rice", and took measures for foods, such as imposing planting restrictions on rice in places where the radioactivity of the produced rice was more likely to exceed the provisional regulation values[4].

In addition, on April 21, 2011, the NERH announced to the Fukushima Governor and the mayors of other related municipalities that it had designated the area located within the radius of 20 km from the 1FNPS as the restricted area, in order to secure the complete safety of residents.

Some evacuees thought that the evacuation was a "temporary refuge of around several days" at the beginning of the disaster occurrence. However, after about 1 month, concerns about the prolonged evacuation life became tangible, and feelings of anger and anxiety spread among evacuees.

（2） Understanding the status of the environmental contamination based on monitoring data and zoning of the evacuation areas

The monitoring data by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) showed areas with high accumulation of radioactive materials in the areas located beyond the radius of 20 km from the 1FNPS. On April 22, 2011, the NERH announced to the mayors of local municipalities that it had newly designated such areas located beyond the radius of 20 km from the 1FNPS as the deliberate evacuation area. In addition, the area between the radius of 20 km and 30 km from the 1FNPS, formerly designated as the sheltering area was designated as the “evacuation-prepared area in case of emergency,” excluding the above “deliberate evacuation area.” The above designation requested the residents in the deliberate evacuation area to schedule their departure from the area, and the residents in the evacuation-prepared area in case of emergency to prepare for evacuation or shelter indoors in case of emergency. In addition, there were certain spots outside the deliberate evacuation area where substantial air dose rates continued to be found and so the annually cumulative exposure dose one year after the accident

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[2] Source: Ministry of Health, Labour and Welfare(MHLW), "Handling of radioactively contaminated food" (March 17, 2011)

[3] The provisional regulation values set on March 15, 2012 are not values established for the emergency response after the accident, but are new values determined from the long-term perspective.

[4] Source: Ministry of Agriculture, Forestry and Fisheries (MAFF), “White Paper on Food, Agriculture and Rural Areas: 2011" (April 24, 2012)

was anticipated to exceed 20 mSv. On June 16, 2011, the NERH designated such locations as “specific spots recommended for evacuation,” by announcing the policy of raising awareness and supporting and promoting the evacuation of residents[5].

On August 3, 2011, the Ministry of Agriculture, Forestry and Fisheries (MAFF) published the "Basic policy on investigation of radioactive materials in rice," and decided to investigate radioactive materials in rice, a stable food in the Japanese diet, at two stages the “preliminary investigation" before harvesting the crop and the "main investigation" after harvesting it[6]. In addition, the MAFF carried out a survey of the radioactive contaminants that targeted a total of about 580 points in Fukushima Prefecture and five surrounding prefectures, and published a concentration distribution map of the radioactive materials in agricultural soil[4].

On August 9, 2011, the NERH announced its concept for the review of the evacuation areas[7]. The announcement stated the evacuation orders had substantial impacts on the lives of residents and it would be appropriate to review the orders, once the status changed because of confirming such as the verification of safety of nuclear reactor facilities and reduction of dose rates through continued monitoring.

Even outside the evacuation area, contamination was found. Also, it became apparent that evacuation had to be inevitably prolonged. Under this situation, some evacuees moved farther from the 1FNPS. Some residents even in non-evacuation areas also moved away farther on their own decision.

Residents were highly worried about the radioactive contamination of the living environment. They proactively collected information about radioactive materials and the status of contamination by themselves because of limited availability of relevant information. As a result, diverse information was circulated regardless of its quality via SNS and other means. In such a situation, prefectural, municipal, and community officials who needed to directly communicate with residents made efforts to soothe the confusion between residents by actively providing residents with the latest information and advice on radiation protection. They had to so act, while responding to the disaster and confirming safety and location of residents, by referring to the information provided by the national and prefectural governments and opinions of experts with whom they had personal contacts, They also lacked sufficient information.

On September 30, 2011, MEXT announced the “Results of nuclide analyses of plutonium and strontium”. These results showed that the effects of plutonium and strontium exposure were much lower in comparison with that of cesium, confirming that the primary concern should be cesium.

The total number of evacuees in the whole of Fukushima Prefecture was about 164,000 at its peak as shown in figure 1-1. The number of evacuees from the evacuation order areas reached 81,000 as of August 8, 2013. Considering that the population in Fukushima Prefecture as of October 2010 was about 2,000,000 as stated in 1.1.1, it can be understood how a lot of people evacuated.

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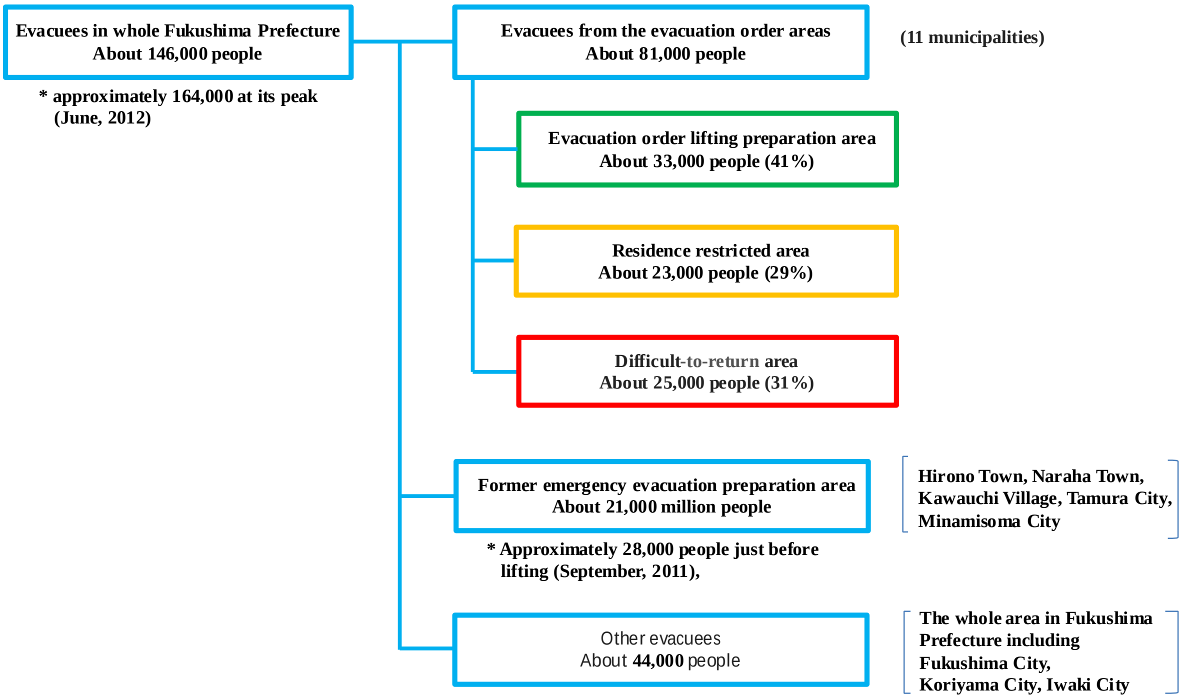
[5]Source: Nuclear Emergency Response Headquarters (NERH), “Addressing the specific spots where the cumulative exposure dose one year after the accident is expected to exceed 20 mSv” (June 16, 2011)

[6]Furthermore, the concentration of radioactive cesium exceeding the provisional regulation values was detected in rice from certain areas after the survey, so rice shipment restrictions were enforced in those areas.

[7]Source: Nuclear Emergency Response Headquarters(NERH), “Concept of the review of the evacuation areas” (August 9, 2011)



(Remarks)

・The refugees from the whole Fukushima Prefecture are based on the damage information bulletin (Part 1031) (September 17, 2013) of the Fukushima Prefecture "Tohoku – Pacific Ocean Earthquake, FY 2011".

・The number of refugees from the evacuation order areas was totaled by the Assistance of Residents Affected by the Nuclear Incidents based on the information caught from municipalities (the number of resident registration as of August 8, 2013).

・The number of refugees from the former emergency evacuation preparation area was totaled by the Assistance of Residents Affected by the Nuclear Incidents based on the information caught from municipalities (as of September 17, 2013).

Figure 1-1 The number of evacuees from the evacuation order areas[8].

（3） Implementation of emergency measures

1）Formulation of response policy

Upon discovery of radioactive contamination even outside the evacuation order areas, emergency measures were also required there and various efforts were made accordingly.

Japan's Act on Special Measures concerning Nuclear Emergency Preparedness stipulated that it was the responsibility of the NERH to resonsd to the nuclear emergency and take post-accident measures in order to prevent the expansion of nuclear disaster and to promote the restoration activities. However, no practical legal framework covering such points as specific methods and framework to address the release of radioactive materials into the environment had been formulated before the accident occurred. Under this situation, the Government immediately formulated and announced provisional policies such as criteria for the treatment of disaster wastes[9], criteria for radiation protection[10], and dose criteria in schools to secure children's living environment[11].

In addition, because radioactive materials which exceeded the provisional standard values prescribed in the Food Sanitation Act were detected in tea leaves grown outside Fukushima Prefecture, the MAFF stopped the shipment of those products and conducted investigations[12].

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[8]Source: Cabinet Office, "Review of the evacuation instructions" (October 2013)

[9]Source: Ministry of the Environment (MOE), "Handling of disaster waste in Fukushima Prefecture for the time being" (May 2, 2011)

[10]Source: Nuclear Safety Commission, "The basic idea about radiation protection and decontamination" (May 19, 2011)

[11]Source: Ministry of Education, Culture, Sports, Science and Technology (MEXT), "Tentative ideas in judging the use of buildings and playgrounds of schools in Fukushima Prefecture" (April 19, 2011)

[12]Source: Ministry of Agriculture, Forestry and Fisheries (MAFF), "White Paper on Food, Agriculture and Rural Areas 2011" (April 24, 2012)

2）Decontamination activities started by various entities

Since the contamination had expanded outside the evacuation order area, some municipalities started their own efforts to reduce radiation exposure. Initially, the emphasis was placed on reduction of children's exposure to radiation.

The pioneers were Date City and Koriyama City. Date City started a demonstration test at a school ground of former Shimooguni Elementary School from April 21, 2011[13]. Koriyama City began to remove topsoil of school grounds from April 27, 2011[14]. In May 2011, a group of experts on radiation from the Japan Atomic Energy Agency (JAEA), in cooperation with Fukushima University, conducted the field survey to verify the reduction measures of air dose in schoolyards and kindergarten yards[15]. As a result, two soil treatment methods were presented: one was to collectively bury soil underground and the other was to vertically displace soil (upside-down plowing (deep plowing)). JAEA then continued monitoring the effectiveness of the dose reduction activities at not only school grounds but also at school swimming pools in municipalities. They also cooperated in the formulation of decontamination guidelines based on their expert knowledge (In those days, the term “decontamination” was not in common use; rather the term “dose reduction activity” was used.)

In addition, experts with knowledge of radiation played the role of decontamination advisors for several municipalities such as Date City, Minamisoma City, and Iitate Village to start decontamination activities (Figure 1-2 shows decontamination work in Date City).

Each municipality, whick lacked knowledge on radiation and sufficient personnel for decontamination conducted dose reduction activities and model decontamination projects[16] by themselves, using available tools, in cooperation with organizations and experts with knowledge of radiation and sometimes with volunteers. These efforts mainly targeted local facilities (or points) such as schools and specific houses. On the other hand, the notion was gradually spread that decontamination of wide area was necessary to obtain sufficient effects in air dose rate reduction.

Under these circumstances, to verify the effects of decontamination over relatively wide areas with various land usage including housing, roads, agriculture, etc., the Cabinet Office entrusted JAEA to start a demonstrative test in Date City and Minami-soma City under a “research project to formulate decontamination guidelines related to the accident at the 1FNPS”. In addition, to verify technologies for area-wide decontamination, the Fukushima Prefecture implemented a wide-area decontamination model project.[17] In the meantime, different range and effects of decontamination among municipalities led to "sense of unfairness" and "sense of dissatisfaction" of some residents.

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[13]Source: Date City, “Three years of history of Date City after the Great East Japan Earthquake and Nuclear Accident” (http://www.city.date.fukushima.jp/soshiki/9/7146.html)

[14]Source: Koriyama City, “History of Koriyama City after the Great East Japan Earthquake” (February 2013)

[15]Source: Ministry of Education, Culture, Sports, Science and Technology (MEXT), “Air dose reduction measures in the schoolyards and kindergarten yards based on fieldwork” (May 11, 2011)

[16]For example, the Fukushima Prefectural Government's model project for radiation reduction measures for ordinary houses

[17]Source: Fukushima Prefectural Government, Fukushima surface decontamination model project (https://www.pref.fukushima.lg.jp/sec/16045c/josen-mentekimoderu.html)

Figure 1-2 Decontamination at Tominari Elementary School in Date City.

Target spots for the decontamination		Area (m²)
Residential land	Roof	4,779
	Wall	5,945
	Garden, etc.	11,204
Rice paddy	Rice field	11,350
Field, Orchard, etc	Field, Orchard	27,325
	Surface of slope	20,705
Forest, etc	Forest, Bamboo forest	16,339
Road	Municipal road	6,866
	Private road, Farm road	148
	Waterway	565
	Others	89
Total		105,315

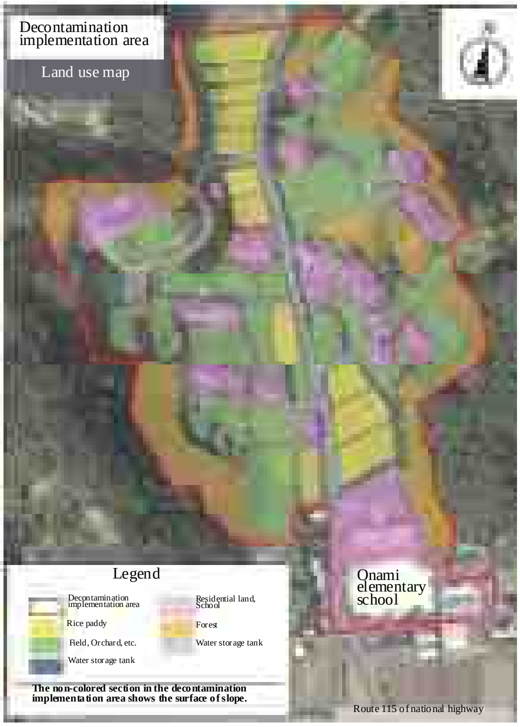

Figure 1-3 Target areas for decontamination of the area-wide decontamination model project by Fukushima Prefecture[18].

JAEA continued enhancing its framework to support the decontamination of each municipality. In addition, since October 2011, Fukushima Prefecture held workshops, in cooperation with JAEA, to develop human resources for decontamination.

At the municipal level, Fukushima City created the manual mentioned in 3) and held workshops for decontamination business operators, in order to develop human resources as well as to provide matching opportunities for local business operators to utilize their own techniques to let them easily enter the decontamination business[19].

18Source: Fukushima Prefecture, "Fukushima Prefecture surface decontamination model project summary version", (February 2012)

19For example, through the workshop, a company specializing in painting and cleaning was found to be good at high-pressure water cleaning, a company specializing in civil engineering was found to be good at

Apart from the above, regarding farmland, since May 28, 2011, MAFF took the initiative to conduct demonstration tests, as seen in Figure 1-4, to verify decontamination technologies for farmland soil in Iitate Village and Kawamata Town. On September 30, 2011, MAFF compiled the publication, “Appropriate Methods for Decontamination of Farmland.” The results of these demonstration tests are included in the decontamination-related guidelines described in (4) 2) of this chapter.

MAFF continued efforts to develop decontamination methods. It started demonstration project for development of farmland decontamination technologies in February 2012[20] including verification at the construction demonstration level and studies toward practical use in the field as shown in Figure 1-5. In February 2013, MAFF compiled the “Technical Book for Farmland Decontamination,” summarizing the features of each method as shown in Figure 1-6.

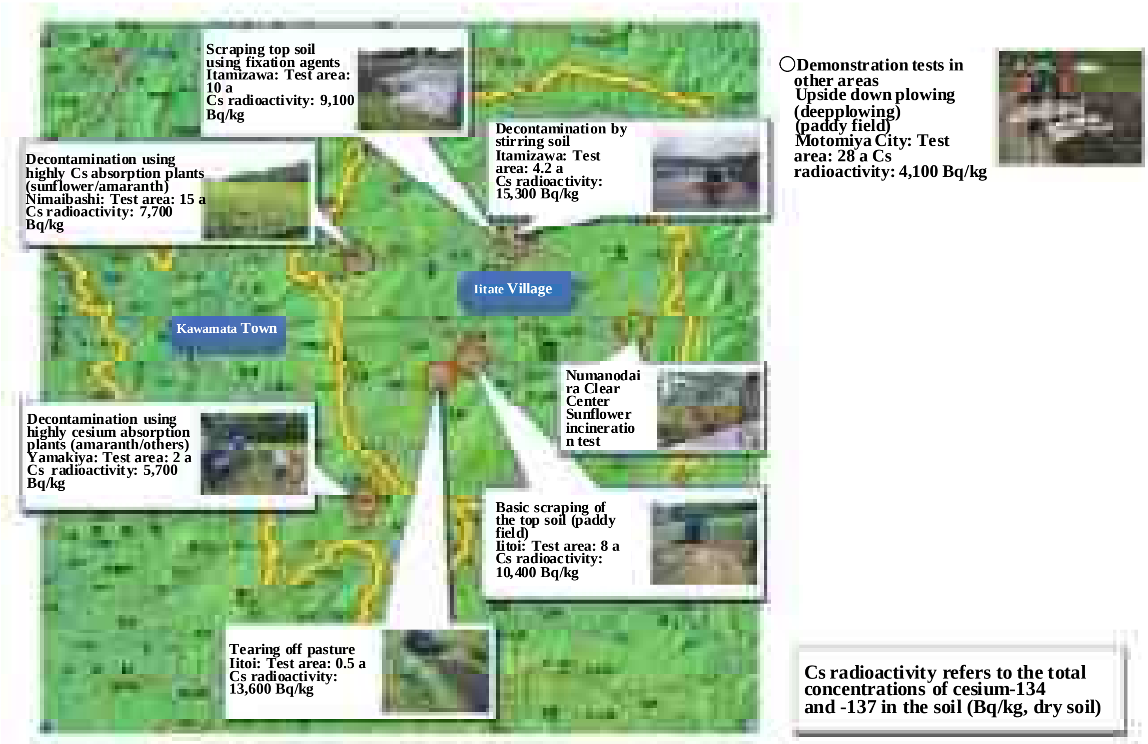

Figure 1-4 Development of decontamination technologies for contaminated agricultural soil – Overview of the demonstration tests[21].

scraping of ground soil.

[20]Source: Ministry of Agriculture, Forestry and Fisheries (MAFF), “Results of the Demonstration Project for Decontamination of Farmland (Interim Report)” and the “Technical Book for Farmland Decontamination” (August 31, 2012)

[21]Source: Ministry of Agriculture, Forestry and Fisheries (MAFF), "Development status of decontamination technology in agriculture, forestry and fisheries" (June 16, 2012), (also the source for Figure 1-5)

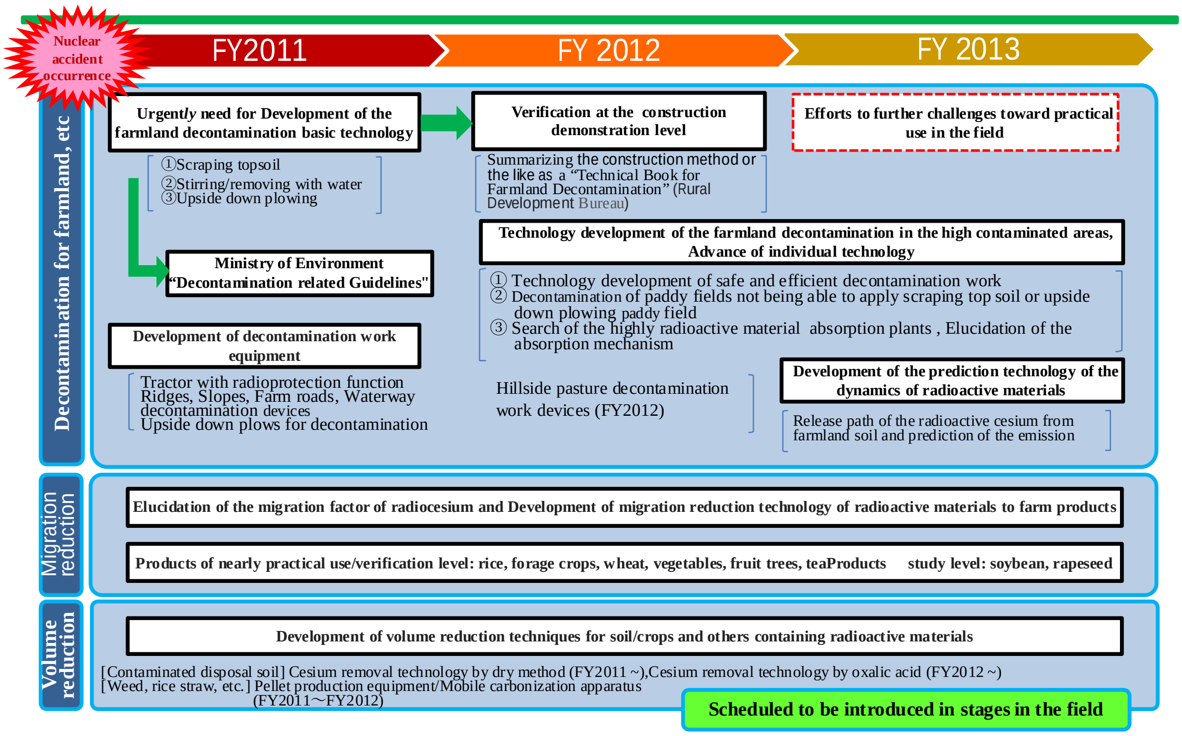

Figure 1-5 Research plan of radioactivity decontamination measures for agriculture after the nuclear accident.

Process	Scraping methods	Feature	Soil water condition	Surface condition	Device versatility	Operator dependence
Scraping	Scraping the topsoil with backhoe	Scraping the topsoil by moving bucket back and forth with backhoe	Wet~Dry	Rough~land leveling	High	High
	Wiper	Scraping the topsoil by letting an arm swing to a horizontal direction using the backhoe fitted an edge to the bucket	Wet~Dry	Rough~land leveling	Middle	Low
Collecting/Transporting	Standard transporting	Packing the scraped soil into the weatherproof large sandbags using backhoe and carry it	Wet~Dry	—	High	—
	Sucking	Sucking the scraped soil through suction pump/hose using the sludge supply and discharge car	Dry	—	Middle	—
	Conveyor	Packing the scraped soil into the weatherproof large sandbags using the screw conveyor type shaving machine	Dry	—	Low	—
Scraping~Collecting/Transporting(continuous)	Skimmer	Scraping the topsoil with horizontally rotating special resin plate and loading the scraped soil into a followed truck for the non-leveling of ground	Dry	land leveling	Low	Middle
	Turf stripper	Scraping the topsoil by letting a lot of small scoop-shaped blades rotate horizontally and loading the scraped soil into a truck running parallel for the non-leveling of ground	Dry	land leveling	Low	Middle
	Rotary cutter	Scraping the topsoil using the lawnmower with the rotary feather fixed to a backhoe and packing the scraped soil into the weatherproof large sandbags in the rear	Dry	land leveling	Low	Middle

Figure 1-6 Options of topsoil scraping methods[22].

[22]Source: Ministry of Agriculture, Forestry and Fisheries (MAFF), "Overview of the Technical Book of Agricultural Land Decontamination Measures" (February 2013)

3）Formulation of manuals for radiation dose reduction measures

As mentioned in 1.1.1, the knowledge of radiation and about its influences on the human body had not been shared sufficiently among ordinary people in Japan before the accident occurred. The accident raised the need for general knowledge on radiation and for information on radiation protection measures for the accident at 1FNPS, especially among people in the affected areas. Several academic organizations with expert knowledge of radiation published Q&A-style radiation guidebooks to provide basic knowledge and information on radiation to the public[23]. The Government and Fukushima Prefecture also issued some pamphlets regarding radiation.

In addition, Fukushima Prefecture, Minami-soma City, and Fukushima City published several manuals for radiation dose reduction measures[24], which contributed to provide people with knowledge not only on radiation but also on decontamination.

Based on these guidelines as well as the results of decontamination activities shown in 2) just above, some municipalities formulated and announced their first decontamination implementation plans based on the "Basic Policy on Urgent Implementation of Decontamination" (to be explained in the following (4)) as early as in the autumn of 2011[25].

The government incorporated the contents of these manuals issued by Fukushima Prefecture and municipalities and the knowledge obtained through decontamination activities including model projects into the "Decontamination Technology Catalog" and the "Decontamination Guidelines" as indicated in (4) 2).

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[23]For example, "Radiation Q&A in Life Answered by Experts" issued by the Japan Health Physics Society, "The Q&A Regarding Radiation Exposure" issued by the Japan Radiological Society, and "The Q&A Regarding the Impact of Radiation Exposure on the Human Body in Association with the 1FNPS Accident" issued by the Japanese Radiation Research Society.

[24]Examples are: Guidance for Reduction of Air Dose in Living Space issued by the Fukushima Prefectural Government (July 15, 2011), Radioactive Material Decontamination Manual issued by the Minami-soma Municipal Government (July 2011), and the Fukushima City Decontamination Manual (1st Ed.) issued by the Fukushima Municipal Government (September 27, 2011).

[25]For example, Date City Decontamination Implementation Plan (1st Ed.) (October 2011); Fukushima City Furusato Decontamination Implementation Plan (September 27, 2011);
Kawauchi Village Decontamination Implementation Plan (1st Ed.) e (September 28, 2011); and Minami-soma City Decontamination Plan (1st Ed.) (November 10, 2011)

Figure 1-7 Excerpt from a brochure on radiation (left) and a guide book on decontamination (right) published by Fukushima Prefecture[26].

（4） Establishment of legal framework and decontamination guidelines

1）Framework of decontamination under the Act on Special Measures and others

While the knowledge about radiation and decontamination was gradually being collected and assembled, as described above, Chairperson of the Environment Committee of the lower house of the Diet presented a bill of the Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District Off the Pacific Ocean Earthquake That Occurred on 11 March 2011 (Law No. 110, 2011) (hereinafter referred to as the Act on Special Measures). The Act was enacted on August 26, 2011 at the upper house plenary session and promulgated on August 30, 2011.

The NERH decided、on August 26, 2011, the Basic Policy on Urgent Implementation of Decontamination[27] as an initiative until the full enforcement of the above act (due January 1, 2012).

The above basic policy stipulated: the decontamination should be operated by the national government for the evacuation areas;, the annual additional exposure dose should be limited to 1 mSv or lower as a long term goal in the region under existing exposure situation (currently 20 mSv or lower for the annual additional exposure); and the national government should provide technical and financial support for local municipalities to develop and implement their decontamination plans. In addition, a fund was created by the supplementary budget of the Cabinet Office to let Fukushima Prefecture subsidize (at a

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[26]Source: Fukushima Prefecture, "To understand radiation correctly and behave properly" (September 2011), and "Guidance related to radiation dose reduction measures in the living space" (July 15, 2011)

[27]Source: Nuclear Emergency Response Headquarters (NERH), Basic Policy on Urgent Implementation of Decontamination (August 26, 2011)

subsidy rate of 100%) the municipalities for decontamination based on their decontamination plans in accordance with the Urgent Implementation Policy.

The same basic policy further stipulated that the national government should continuously provide technical information necessary for the decontamination such as, on effective methods, their cost, and considerations due (the Decontamination Technology Catalog), through model projects in each area, including particularly high dose areas. In this regard, the NERH presented the "Guidelines for the Implementation of Decontamination in Municipalities [28]" for relevant municipalities to formulate and implement their decontamination plans.

On November 11, 2011, the Basic Principles on the Act on Special Measures was authorized by the Cabinet. Taking over the concept of the Basic Policy on Urgent Implementation of Decontamination Works, the new Basic Policy stipulated that the annual additional exposure dose would become below 1 mSv in the long-term in the area where the annual additional exposure dose was currently below 20 mSv, and that the national government was responsible for treating the wastes and wastewater sludge exceeding a certain level of radioactivity.

In the meantime, on October 29, 2011, the MOE announced the "Basic Concept of the Interim Storage Facility (ISF) Necessary in Dealing with Environmental Pollution Caused by Radioactive Materials in Association with the Accident at the 1FNPS of TEPCO," which stipulated the policies to install the interim storage facility at one location in Fukushima Prefecture for handling contaminated soil and wastes produced in the prefecture and to finally dispose of such waste outside Fukushima Prefecture within 30 years after starting of interim storage.

On December 22, 2011, the MHLW promulgated the "Ordinance on Prevention of Ionizing Radiation Hazards Associated with Decontamination Works to Decontaminate Soil and Wastes Polluted by Radioactive Materials Resulting from the Great East Japan Earthquake" (hereinafter referred to as the Ionizing Radiation Ordinance for Decontamination), a framework to prevent the ionizing radiation hazards associated with decontamination work.

By such legal arrangements, the legal framework for implementing decontamination work in Japan has been fixed.

2）Decontamination guidelines

On November 22, 2011, the Cabinet Office issued the "Decontamination Technology Catalog" and on December 14, 2011, the MOE formulated and published the "Decontamination Guidelines" that systematically compiled the decontamination methods in accordance with the Act on Special Measures. The guidelines based on the Act on Special Measures explained in an easy-to-understand manner the processes to survey and measure the extent of contamination, implement the decontamination, and collect, transport, and store removed soil associated with decontamination work (See Chapter 2 for details).

On December 22, 2011, simultaneously with the announcement of the Ionizing Radiation Ordinance for Decontamination, the MHLW formulated and announced the "Guidelines for Prevention of Radiation Hazards to Workers Engaged in Decontamination Works," which are the guidelines to prevent health hazards to workers associated with decontamination operations.

On December 27, 2011, the MOE formulated and announced the "Waste Guidelines" (the guidelines for processing waste contaminated by nuclear accident-derived radioactive materials).

In March 2012, the MOE formulated and announced the "Guidelines for Addressing Localized Contaminated Spots by Radioactive Materials," which are the guidelines summarizing the efficient locating methods, in-depth survey methods, and handling precautions of localized contaminated spots.

Most of the guidelines were thus developed toward the end of JFY2011. j

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[28] Source: Nuclear Emergency Response Headquarters (NERH), Guidelines for the Implementation of Decontamination in Municipalities (August 26, 2011)

（5） Efforts toward the full-fledged decontamination under a unified framework

1）Decontamination projects by the Cabinet Office

In response to the establishment of the Basic Policy on Urgent Implementation of Decontamination Works, the Cabinet Office entrusted the project for a decontamination model to JAEA. The project primarily targeted the areas with annual additional exposure dose exceeding 20 mSv and had the aims of establishing efficient and effective decontamination methods and measures of radiation protection for workers (started in November 2011; see 1.1.6 for details).

The Cabinet Office also delegated the project to demonstrate decontamination methods to JAEA, in order to publicly solicit new decontamination technologies that can be practicable and to evaluate their effectiveness.

2）Cold shutdown state of nuclear power station and rezoning of the evacuation areas

On December 16, 2011, the NERH judged that the safety of the entire power station was comprehensively secured by the achievement of the cold shutdown state of the reactors. Thus, it was confirmed that the target of step 2 in the roadmap, a state where “the release of radioactive materials came under control and the radiation dose was significantly suppressed,” was achieved.

Under this situation, on December 26, 2011, the NERH compiled the “Basic Concept and Future Tasks in Review of the Restricted Areas and the Evacuation Order Areas after the Completion of Step 2”; the basic concept to start a concrete review of the restricted areas and the evacuation order areas, including the preparation for lifting the evacuation order of the areas with low dose rates by further advancing the decontamination work, with the targeted time schedule to finish the review by March 30, 2012.

In response to the above, on January 26, 2012, the MOE announced the “Decontamination Policy of the Special Decontamination Area” (Decontamination Roadmap),” describing the flow of decontamination projects (demonstration model projects, preliminary decontamination, and full-scale decontamination) and the processes for each area.

As for lifting of evacuation orders, it was prescribed that development of livelihood infrastructures and restoration of municipal office functions should be promoted together with decontamination because the objective of lifting of evacuation orders was to assure returning of residents and reconstruction of their lives.

3）Establishment of a system toward full-scale decontamination

On August 24, 2011, before the establishment of the Act on Special Measures, the Fukushima Decontamination Promotion Team was established mainly by the MOE in cooperation with the Cabinet Office and JAEA to support the formulation of decontamination implementation planning by municipalities in Fukushima Prefecture. The team started its operation in September 2011, immediately after the promulgation of the Act on Special Measures, in cooperation with the Nuclear Emergency Response Local Headquarters (hereafter referred to as the Local NERH)), to communicate and coordinate with municipalities and to help the formulation of decontamination plans (including dispatch of experts). The team also promoted the national decontamination model projects in twelve municipalities in the restricted area, deliberate evacuation areas, etc .

In academic and private sectors, in May 2011, the Atomic Energy Society of Japan (AESJ) established the “Clean-up Subcommittee[29]” to actively provide support to the restoration activities of environmental contamination by radioactive materials. In November 2011, the “Society for Remediation of Radioactive Contamination in the Environment (SRRCE)[30],” which was mainly dealing with the subject of

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[29]Source: Fukushima Special Project, Clean-up Subcommittee, Project Leader Tadashi Inoue, The objectives of the establishment of AESJ CU Subcommittee and its activities (January 20, 2013)

[30]Source: The Society for Remediation of Radioactive Contamination in the Environment (SRRCE) Website (http://khjosen.org/)

decontamination, and the “Technical Advisory Council on Remediation and Waste Management[31]” by industry groups, were established.

On January 4, 2012, upon the full enforcement of the Act on Special Measures, the MOE established the “Fukushima Environmental Restoration Office” as a base to promote decontamination and revive the natural environment in Fukushima Prefecture. To promote decontamination in the Special Decontamination Area, the office coordinates the operations with eleven municipalities in the same areas, implements decontamination projects, and coordinates or cooperates with the Local NERH. In addition it consults and coordinates plans and project details of decontamination implemented by municipalities in Fukushima, Miyagi, and Iwate Prefectures. The office has five branches in Fukushima Prefecture to provide detailed support to municipalities (in addition to the five branches, on December 5, 2014, the Hamadori Office for the Interim Storage Facility was fonded to address the issues of the interim storage facility)[32].

On January 20, 2012, the Decontamination Information Plaza was jointly established near Fukushima Station by the MOE and Fukushima Prefecture to play the role of base facility to provide the general public with information on decontamination and radiation and to dispatch registered experts. The structure toward full-scale decontamination was steadily being built. JAEA and AESJ dispatched expert personnel to the Decontamination Information Plaza and the Fukushima Environmental Restoration Office.

On March 12, 2012, TEPCO established an office under the organization of the Environmental Department in its Fukushima Office to monitor the environmental radiation by resident employees and to provide support for the decontamination efforts in Fukushima. From April 7, 2012, the Federation of Electric Power Companies of Japan dispatched decontamination experts to support the decontamination activities in Fukushima, in addition to providing personnel to the Decontamination Information Plaza upon request.

In addition, the Japan Society of Civil Engineers (JSCE) established the “Specific Theme Committee to Address Radioactive Waste” under the “Great East Japan Earthquake Special Committee,” to carry out full-fledged activities from the beginning of 2012[33]. In April 2012, the Japan Federation of Construction Contractors established the Decontamination Committee under the Electric Measures Special Committee to establish the framework to implement decontamination projects for the entire construction industry.

On January 1, 2013, TEPCO established the “Fukushima Revitalization Headquarters” and the Decontamination Promotion Office within it to provide further cooperation on decontamination.

As seen above, with the establishment of the Act on Special Measures, the efforts and roles of national, prefectural, and municipal governments were restructured. As their roles were more clearly defined (Fig.1-8) and as their features became to be more utilized, the entire structure in Japan was optimized, and systematic cooperation between industry and academia was accelerated.

In the meantime, from February 8, 2012, the Fukushima Prefectural Government held meetings of the Study Committee for the Basic Concept of Environmental Recreation Strategic Base[34]. The committee studied the establishment of the “Center for Environmental Recreation,” the base facility to address the restoration and recreation of the environment contaminated by radioactive materials, under close cooperation among Fukushima Prefecture, JAEA, and the National Institute for Environmental Studies (NIES). The center is scheduled to open in FY2016 (a part of the facility is opening in FY2015) to provide residents with information such as monitoring of environmental radioactivity, status of the environmental decontamination for the remediation and recreation of the environment, tracking movements of radioactive materials, research and evaluation of decontamination methods, and the results of monitoring and surveys, and in addition to provide education, training, and exchanges to develop creative power for Fukushima's future[35].

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31 Source: Technical Advisory Council on Remediation and Waste Management Website (http://tacrwm.jp/01_about/01_01_objective.html)

32 Source: Ministry of the Environment (MOE): "Fukushima environmental remediation office"

33 Source: Japan Society of Civil Engineers: JSCE Great East Japan Earthquake Special Committee - One Year of Activities, Achievements, and Proposal (March 2012)

34 Source: Fukushima Prefecture Website （https://www.pref.fukushima.lg.jp/sec/16035d/meeting-basicplan.html ）

35 Source: Center for Environmental Recreation Operative Strategy Meeting: Mid- and long term policy for the environmental recreation center (February 2015)

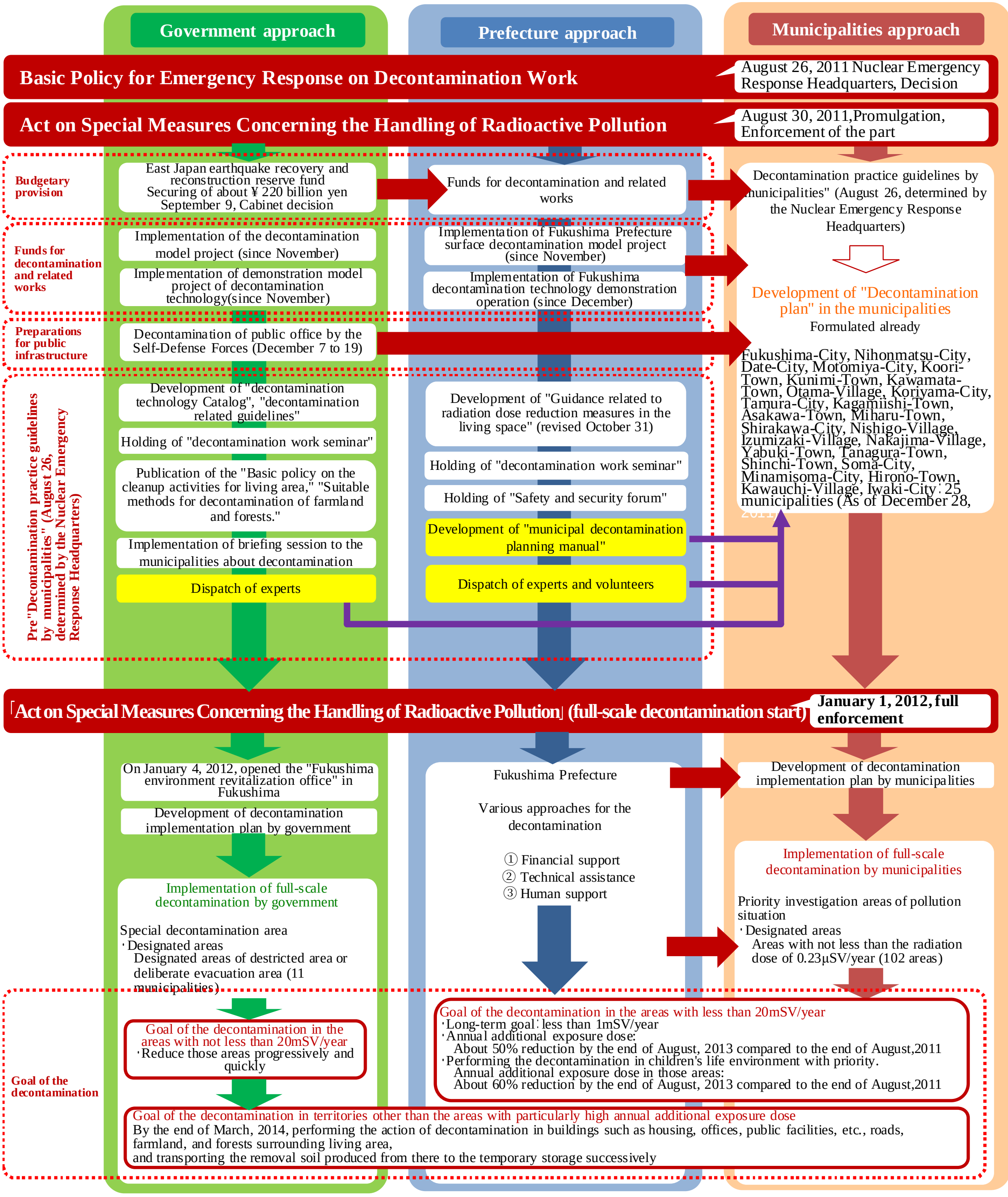

Figure 1-8 Decontamination approaches by government, prefectural and municipal authorities[36].

In October 2011, the International Atomic Energy Agency (IAEA) visited Fukushima, reviewed the decontamination works performed by Japan and provided advice on them. The results were compiled in the form of the “Final Report by the International Mission Regarding Remediation of Large Contaminated

[36]Source: The nuclear disaster victims life support team by the government: “Interaction with the public, newsletter No. 9 ‘ (News from the nuclear disaster victims life support team by the government)” (January 15, 2012)

Areas Off-site the Fukushima Daiichi Nuclear Power Plant.” The report described nine areas of significant improvement and gave recommendations on twelve points to the Japanese government.

- Examples of nine highlights of important progress and recommendations on twelve points which were described in the Final Report[37] by the International Mission Regarding Remediation of Large Contaminated Areas Off-site the Fukushima Daiichi Nuclear Power Plant[38].

【Examples of nine highlights of important progress】

- The Mission Team appreciates that Japan has gone forward very quickly and allocated the necessary legal, economic and technological resources to develop an efficient remediation programme to bring relief to the people affected by the Fukushima Dai-ichi nuclear accident. Priority has been given to children and the areas that they typically frequent.
- The Fukushima Decontamination Promotion Team, which consists of resident staff in Fukushima from the Ministry of the Environment (MOE), the Local Emergency Response Headquarters and the Japan Atomic Energy Agency (JAEA), coordinates and shares information with relevant ministries and agencies, and communicates with and provides technical support to the Fukushima prefectural and relevant municipalities. The Mission Team welcomes Japan’s efforts to establish a practical catalogue of remediation techniques
- The Team considers the use of demonstration sites to test and assess various remediation methods to be a very helpful way to support the decision-making process.

【Examples of recommendations on twelve points】

- The Japanese authorities involved in the remediation strategy are encouraged to cautiously balance the different factors that influence the net benefit of the remediation measures to ensure dose reduction. They are encouraged to avoid over-conservatism which cannot effectively contribute to the reduction of exposure doses. This goal could be achieved through the practical implementation of the Justification and Optimization principles under the prevailing circumstances. Involving more radiation protection experts (and the Regulatory Body) in the organizational structures that assist the decision makers might be beneficial in the fulfillment of this objective. The IAEA is ready to support Japan in considering new and appropriate criteria.
- It is appropriate to consider further strengthening coordination among the main actors, through the establishment of a more permanent liaison between the organizational structures of the Government of Japan and the prefectural and municipal authorities.
- Before investing substantial time and efforts in remediating forest areas, a safety assessment should be carried out to indicate if such action leads to a reduction of doses for the public. If not, efforts should be concentrated in areas that bring greater benefits. This safety assessment should make use of the results of the demonstration tests.

（6） Progress of decontamination in the Special Decontamination Area and the Intensive Contamination Survey Area

1）Progress of decontamination in the Special Decontamination Area

The decontamination in the Special Decontamination Area (see 1.1.5 for details) was started from the peripheral areas of municipal offices by the Self-Defense Forces, which would serve as the bases for full-scale decontamination activities later. Also, the decontamination of

[37]Source: IAEA, ”Final Report of the International Mission on Remediation of Large Contaminated Areas Off-site the Fukushima Daiichi Nuclear Power Plant” (November 15, 2011) (http://www.mofa.go.jp/mofaj/saigai/pdfs/iaea_mission_1110_en.pdf)

[38]Source: Excerpt from IAEA “Final Report of the International Mission on Remediation of Large Contaminated Areas Off-site the Fukushima Daiichi Nuclear Power Plant; Draft translation (Summary portion only)” (November 15, 2011)

future operational bases such as other public facilities was made by the MOE. Additionally, the decontamination model projects were started in March 2012 in the restricted area of the Joban Expressway, an important piece of transportation infrastructure. These activities were conducted as part of overall strategic efforts, which had the objectives of establishing effective decontamination methods, while obtaining data to help implement smooth large-scale decontamination, instead of just conducting large-scale decontamination without a strategy.

The progress in review of evacuation zoning differed by municipality in the Special Decontamination Area. On March 30, 2012, zoning in parts of the restricted areas in Tamura City, Kawauchi Village, and Minami-soma City were changed and these were newly designated as evacuation order areas. In April 2012, the MOE formulated decontamination implementation plans for Tamura City, Naraha Town, Kawauchi Village, and Minami-soma City, earlier than for other municipalities. On July 25, 2012, the MOE started the first full-scale decontamination in the Special Decontamination Area in Tamura City. Then, although there were differences in progress among municipalities in the Special Decontamination Area, the decontamination plans were gradually formulated, followed by full-scale decontamination.

According to the Act on Special Measures, the consent of a large number of concerned parties was required before starting the decontamination. It took a very long time to identify the land owners and stakeholders, to pay attention to residents' feelings, and to provide considerations and detailed explanations to obtain consent of all involved. Furthermore, with the large- and full-scale decontamination works having started, the operators were required to secure a large number of workers, provide education on labor safety and decontamination works, and secure qualified workers. Each operator made various efforts to address these mounting tasks. In the meantime, the national government kept collecting knowledge and information on new discoveries from actual decontamination works, shared the information with the public in a timely manner, and reflected such summaries in the form of specifications to the decontamination business operators (See Chapter 4 for details).

2）Progress of decontamination in the Intensive Contamination Survey Area

In the Intensive Contamination Survey Area (see 1.1.7 for details), some municipalities had already conducted the decontamination before the full enforcement of the Act on Special Measures. They utilized the knowledge obtained from their experiences and continued the decontamination after the enforcement of this Act.

For example, based on the experience that it was important to form a consensus with local residents before starting the decontamination, Fukushima City allowed the residents' involvement from the planning stage of decontamination as shown in Figure 1-9. The city established 18 “regional decontamination measure committees” consisting of officers of the autonomy promotion council, PTA, and local city council members. The city also conducted “decontamination implementation review meetings,” consisting of leaders of neighborhood associations to confirm the flow of rainwater and surface water in each community and study the work orders for decontamination. Minami-soma City made efforts to seek agreement among residents to secure temporary storage sites by establishing the selection criteria for candidate sites by themselves and explaining them to residents as shown in Table 1-1. In Kawauchi Village, dosimeters were distributed to all families, so that residents themselves were able to measure the dose before and after decontamination.

Such efforts to involve residents in the decontamination were also seen in several municipalities outside Fukushima Prefecture. For example, in Kashiwa City, Chiba Prefecture, the “Dialog Meeting toward Safe Living organized by the Association to Promote Decontamination in Kashiwa City[39]” was held during November 21-23, 2011, to have sufficiently long discussions with citizens. Consequently, the city formulated its

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[39]Source: Kashiwa City Website（http://www.city.kashiwa.lg.jp/soshiki/080800/p010072.html）

decontamination implementation plan in March 2012[40]. In the case of Kashiwa City, as a result of the above efforts, the decontamination implementation plan allowed much involvement of citizens by stipulating enhanced support for citizens and volunteers in the decontamination implementation.

On the other hand, some municipalities were not able to establish temporary storage sites. Some took a long time to decide the scope of decontamination and the formulation of the decontamination implementation plan because they were not able to reach agreement with residents.

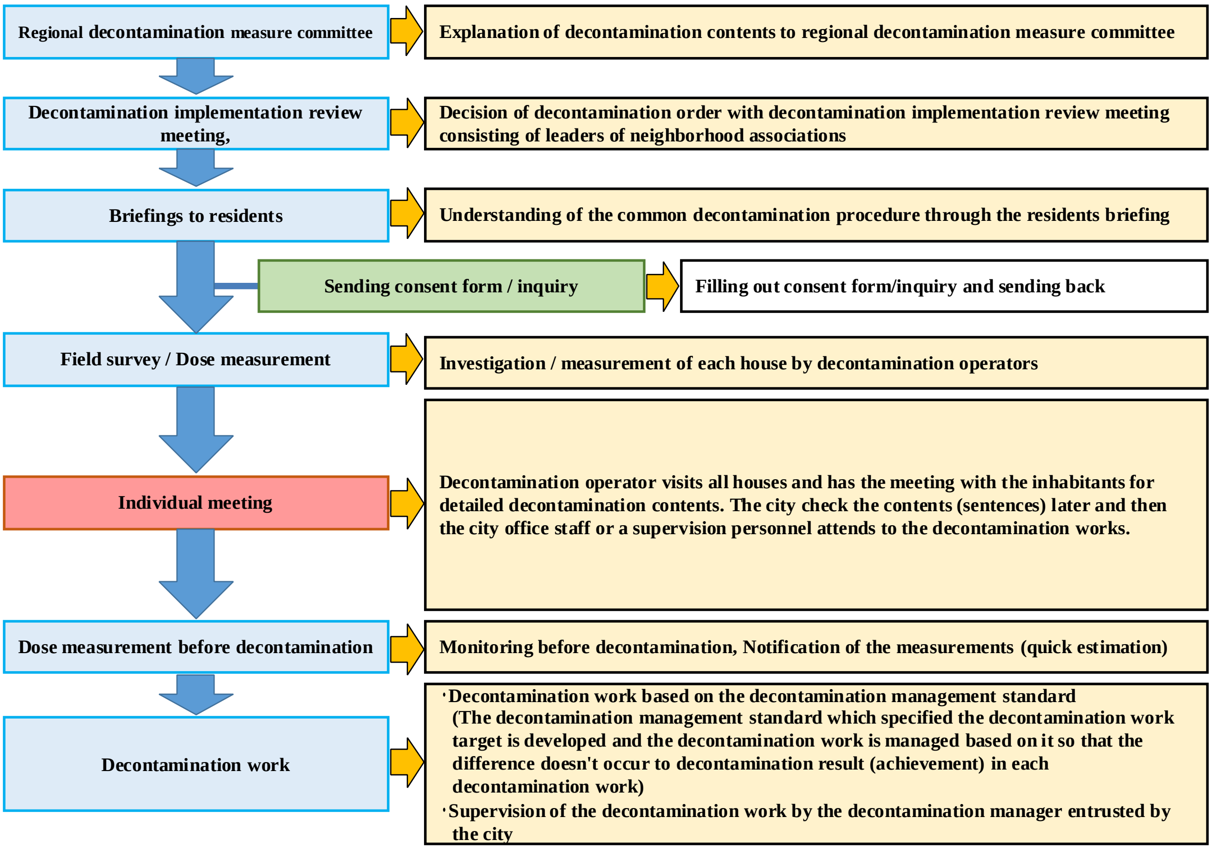


Figure 1-9 Procedure for housing decontamination (Fukushima City)[41].

[40]Source: Kashiwa City Website（http://www.city.kashiwa.lg.jp/soshiki/080800/p011077.html）
[41]Source: Fukushima City, "An approach to the decontamination in Fukushima City" (February 28, 2013)

Table 1-1 Criteria for selecting candidate site for temporary storage[42]

Viewpoint	Items for selecting site	Criteria for electing site	Reason
Use of land	Securing of site area	Securing of site area not less than 10,000m^2	Production of a large amount of removed radioactive substances
	Securing of access road	Securing of access road not less than two traffic lanes	Access of large vehicles and heavy industrial machinery, etc.
Environment protection	Distance from the surrounding housing, school and hospital, etc.	Distance between candidate site and the neighboring houses, school and hospital, etc.	Impact on consensus
	Risk of secondary disaster	Outflow of radioactive materials and geological feature	
	Influence of water quality, animals and plants	No influence on water quality, animals and plants.	
Cost performance	With or without site renovation	Preparation of sites suitable for storage and control of the removed soil	Impact on decontamination work schedule and project costs
	With or without site acquisition	Site acquisition in the case of non-public land	
Agreement	Land owner	Land owners' cooperation and understanding in the case of non-public land	Impact on decontamination work schedule
	Agreement with local residents	Cooperation and understanding of the surrounding residents	

(7) Efforts based on the experiences of decontamination

On October 23, 2012, the MOE compiled the “Decontamination Promotion Package,” in order to accelerate the decontamination works and eliminate anxiety among residents. The above package recommended measures to accelerate decontamination works, such as transfer of authority to the Fukushima Environmental Restoration Office, expansion of outsourcing of

[42]Source: Minami-soma City, "The situation of the decontamination in Minami-soma City" (October 22, 2013)

the negotiation of obtaining residents' consent to the private sector, and securing of decontamination workers from a wide area. Moreover, it further recommended the measures to obtain residents' consent and eliminate anxiety among residents, which was the major problem then, such as disclosure of information about the effects and progress of decontamination and strengthening of risk communication about decontamination.

Then, in November 2012, the “progress of decontamination in the Intensive Contamination Survey Area” was announced, and in March 2013, the “progress of decontamination in the Special Decontamination Area” was announced, more publicly disclosing the overall progress of decontamination.

In the meantime, in January 2013, one year after the full enforcement of the Act on Special Measures, upon receipt of reports about questionable decontamination operations, the MOE immediately established the headquarters for proper decontamination promotion to investigate the questionable cases. At the same time, the Ministry compiled the “appropriate decontamination program” consisting of three items: (1) enhancing established work responsibilities of business operators through unannounced inspections; (2) building a wide range of management systems by using effective monitoring by a third party; and (3) using the MOE organization effectively such as designating a telephone hotline to accept reports regarding questionable decontamination operations. Through these measures, the MOE tried to eliminate questionable decontamination operations and recover the confidence of residents.

Furthermore, based on the knowledge to the date, the MOE formulated the second edition of the Waste Guidelines in March 2013 and the second edition of the Decontamination Guidelines in May 2014. In April 2013, the MHLW formulated the “Guidelines to Prevent Radiation Hazards of Workers Engaged in the Disposal of Radioactive Materials Discharged by the Accident. Thus various guidelines were revised or expanded based on the experiences of decontamination progress.

In addition, with accumulation of good practices, in May 2013, the Fukushima Environmental Restoration Office compiled the “Examples of Good Practices in Decontamination” and distributed its copies to the decontamination business operators. This booklet introduced two categories of good practices with seven examples each: one category is technical good practices such as survey measurement technologies, decontamination technologies and decontamination operation management technologies, and the other category is communication good practices with the residents including the promotion of understanding and risk communication (See Figure 1-10 for examples).

On June 29, 2013, the full-scale decontamination operations that were the first full-scale project in the Special Decontamination Area were completed in Tamura City.

Example 1 of the approach: Measurement of the spatial dose rate in high places such as roof and rain gutters

(Fukushima City, Koori Town)

[Challenge]

The grasp of the accurate pollution status of target facilities is necessary to promote the decontamination efficiently and to control its quality. In addition, the simplified measurement technique such as without footings is required when the measurement of the spatial dose rate in high places such as roof and rain gutters is required.

[approach]

By attaching a radiation measurement device to the tip of the long things such as extension pole or wash-line pole, it was done that the measurement personnel could measure the spatial dose rate in high places from the ground. With this method, it can be made easily to measure the spatial dose rate in high places.

Example 1) Example of Fukushima City:
With attaching the sensor of the NaI scintillation counter to the tip of the wash-line pole, air dose rates in the vicinity of a height of approximately 3m can be measured from the ground.

Example 2) Example of Koori Town:
With attaching a small video camera, a small radiation dose measuring instrument and communication a small radiation dose measuring device to the tip of the pole, the system which can receive the picture of the video camera with a monitor at hand was built.
By photographing together the measurement instrument display screen and the surrounding landscape with the video camera, pollution and radiation dose of the corresponding location can be confirmed on the ground monitor (tablet screen).

[Reference photograph]
Example 2) Example of Koori-Town:
〇Measurement scenery

Figure 1-10 A good practice: Measurement of air dose rates in high places such as rooves and rain gutters[43].

[43]Source: Fukushima Environmental Restoration Office of the Ministry of the Environment "Good practices of decontamination " (May 2013)

(8) Comprehensive review of the decontamination progress and review of the decontamination implementation plans in the Special Decontamination Area

In September 2013, the MOE announced the "Comprehensive Review of the Decontamination Progress." The review indicated the variations in progress among municipalities, because of the time required for reaching agreement with residents and securing temporary storage sites, and also the weather conditions such as winter snowfalls (Figure 1-11).

In particular, it was difficult to secure the sites for temporary storage and to acquire the consent for decontamination. Some residents were angry to have their area be selected as temporary storage for the wastes that they were not responsible for. Some feared that the temporary storage site ultimately would become the final disposal site without due consultation. Some feared the accumulation of contaminated soil. Some had different opinions about how to operate the decontamination. In all cases, because of the basic policy to fully respect the will and consent of residents before proceeding with the decontamination, there was no way but to build a trusting relationship and improve the understanding about temporary storage and decontamination. In this regard, not only the national and the local governments, but also the decontamination business operators and each worker made strenuous and consistent efforts.

・Since the situations of decontamination were different in each municipality, there was the variation in the progress of decontamination among municipalities. The importance of dealing with future issues based on the experience until now and promoting the decontamination in connection with the progress of restoration was enhanced. indicated the variation in progress among municipalities,
・The original target schedule was revised to allow a flexible decontamination schedule in accordance with the situation of each municipality after consulting with local inhabitants.

Review of the current situations

Since the situations of decontamination were different in each municipality as described below, there was the variation in the progress of decontamination among municipalities.

Cases which needed the time for adjustment before starting decontamination are as follows;
- **Review of the decontamination areas, development of the decontamination plan**
- **Securing the site for temporary storage, Obtaining informed consent for decontamination**
- **Corresponding to the concern about the influence on health of radiation and the effect of the decontamination**
- **Corresponding to the worry about that a transfer destination of the removed soil is not clear, because a plan for the establishment of interim storage installation isn't fixed.**

Cases which needed the time for the conditions of the decontamination site are as follows;
- **Natural influence such as snowfall**
- **Addition of compensation duties**
- **Development of the work procedures and the decontamination schedule in accordance with the situation of each municipality and progress of restoration.**

Future challenges based on experience
- **Ensuring of workers (labor-intensive decontamination work)**
- **Enhancement of safety measures (beginner for many workers)**
- **Load to traffic and waste disposal treatment (movement of the workers and transportation of the removed soil, processing of waste generated from the worker lodgings)**

Coordination with the situation of restoration
- **Facilitation of coordination between the decontamination work and restoration projects (infrastructure preparation, restoration base servicing, changeover of land use, etc.)**
- **Review of the decontamination implementation plan based on the returnees expected timing**
- **Review of the decontamination implementation plan taking into account the differentiation of the indication of residents' will on their intention of return and the time,**

Future direction
- **Revise the original target schedule, which would complete the decontamination and transfer the waste and soils to temporary storage without exception within two years, and promote the decontamination schedule in accordance with the situation of each municipality and progress of restoration.**
- **In that case, in addition to taking appropriate measures for acceleration and facilitation of decontamination, reconsider the original schedule of the decontamination flexibly in accordance with the situation of each municipality and progress of restoration.**
- **In Tamura City, measures of the decontamination and related works based on the decontamination plan were completed. In Naraha Town, Kawauchi Village and Okuma Town , completion of the decontamination will be aimed at by the end of fiscal year 2013 according to the current decontamination plan. In Minamisoma City, Iitate Village , Kawamata Town , Katsurao Village , Namie Town and Tomioka Town , the present decontamination plan is continued to be adjusted with each municipality, and will be changed by the end of the year. In Futaba Town, the adjustment is continued to be performed with the municipality towards the development of the decontamination plan in connection with the consideration of the progress of restoration**

Figure 1-11 Review results of the current decontamination plans, etc. in the Special Decontamination Area[44].

[44] Source: Ministry of the Environment (MOE), "Overall review of the progress of decontamination"

Therefore, the original target schedule, which would "complete the decontamination and transfer the waste and soil to temporary storage sites in all cases within two years," was revised to allow a flexible decontamination schedule in accordance with the situation of each municipality and progress of restoration. Then where the progress differed by municipalities, the plans were revised to better fit with the actual situation. Also reviewed was the conventional way of forest decontamination that had been previously conducted in a range of about 20 meters from the forest edge. In the revision, for the forest surrounding the residential areas in valleys with high dose rates as shown in Figure 1-12, if the dose rates in the area surrounding the residential area was still relatively high after area-wide decontamination, effective decontamination exceeding the 20-meter range from the forest edge was allowed on an exceptional basis.

In the meantime, the Forestry Agency, working from the viewpoint of forestry regeneration, has implemented a demonstration project to integrally promote the forest maintenance and measures against radioactive materials. As a demonstration project, in forests in the Intensive Contamination Survey Area, forest maintenance practices such as thinning were mainly operated by public entities of the prefecture and municipalities. Also, through conducting the disposal and reducing the amounts of foliage generated from forest maintenance, and through creating wood fences to control the diffusion of radioactive materials, the Forestry Agency has conducted efforts to collect knowledge necessary for the smooth maintenance of forests in the areas affected by radioactive materials.

In December 2013, the review of each decontamination implementation plan based on the comprehensive review was conducted and the "Review of the Decontamination Implementation Plans in the Special Decontamination Area" was announced.

Area A (forest surrounding the residential areas)
･If the effect of decontamination with the removal of the deposited organic matter such as fallen leaves, can not be obtained, it is permitted to remove the residue of accumulated organic matter additionally in a range of 5-meter from the forest edge as a rough indication (as the outflow of sediment is concerned, preventive measures against it such as the setting of the sandbag must be appropriately carried out depending on the situation in the field). ･For the forests surrounding the residential areas in valleys with high dose rates , effective decontamination work beyond 20-meters from the forest edge may be exceptionally continued on the case-by-case basis, if the dose in the area surrounding the residential area was still relatively high after the ongoing decontamination work is finished over relatively wide areas.
Area B (Forest users and workers enter on a daily basis)
･For bed log laying yard, if the continuation and restarting of cultivation are expected, it is permitted to remove the accumulated organic matter, such as fallen leaves, in the cultivated land and in the area in the reach of about 20m of its surrounding, according to the decontamination method of forest in area A,
Area C (forest except area A and B)
･The Ministry of Environment takes a new approach based on the indications concerning the possible outflow of radioactive materials to the living area from the area where understory vegetation is decline partially weathering. ･In the Forestry Agency, a demonstration project is advanced from the point of view of forest regeneration to the decontamination of the forest where it is located outside of the living area and forestry was carried out, while dealing with radioactive materials.

Figure 1-12 Future direction of decontamination works in forests[45].

In the meantime, the policy for rivers and lakes was also announced. Previously, due to the shielding effect of water, the existence of inflow sediment from the land, and the movement within the watersheds, it was planned to study measures after accumulating investigation results and research while conducting regular monitoring. In August 2014, the MOE announced the "summary of concept in the future measures for rivers and lakes". It stated that "the decontamination should be made as needed in the living zones with many public activities and with high dose rate due to accumulation of radioactive cesium, when water is dried up and no shielding effect is expected".

In October 2013, when the "Comprehensive review results of the progress of decontamination" was announced, as a follow-up to the IAEA international mission two years earlier, the IAEA follow-up mission team visited to confirm the progress of the situation and to compile recommendations as given below.

(September 2013)

[45]Source: Forestry Agency: "Forest /forestry white paper in fiscal year 2013" (May 30, 2014)

- Examples of thirteen highlights of important progress and recommendations on eight points which were shown in the "Final Report: The Follow-up IAEA International Mission on Remediation of Large Contaminated Areas Off-Site the Fukushima Daiichi Nuclear Power Plant"[46,47]

【Examples of thirteen highlights of important progress】 ➢ The Team acknowledges the institutional arrangements implemented by Japan to address the remediation needs of the areas affected by TEPCO's Fukushima Daiichi NPP accident. The Team appreciates that Japan makes enormous efforts to implement the remediation programme in order to reduce exposures to people in the affected areas, to enable, stimulate and support the return of people evacuated after the accident, and to support the affected municipalities in overcoming economic and social disruptions. The review Team recognizes the involvement of a wide range of ministries and agencies, as well as institutions of the municipalities, to support remediation by providing financial resources, technical guidance and institutional assistance. ➢ The Team welcomes the critical evaluation of the efficiency of the removal of contaminated material compared with the reduction in dose rate offered by different methods of decontamination, recognizing that this is an important tool in the application of decontamination methods. In addition, the Team notes a welcome change from guiding remediation efforts based on surface contamination reduction, to a reduction in air dose rates. This is leading some municipalities to conclude that an additional 1 mSv per year is more applicable to long-term dose reduction goals. ➢ The Mission Team found significant progress in the development and implementation of temporary storage facilities by municipalities and the National Government for contaminated materials generated by on-going remediation activities. In addition, the Mission Team notes the progress made towards the establishment of interim storage facilities by the National Government with the cooperation of municipalities and local communities. 【Examples of recommendations on eight points】 ➢ Japanese institutions are encouraged to increase efforts to communicate that in remediation situations, any level of individual radiation dose in the range of 1 to 20 mSv per year is acceptable and in line with the international standards and with the recommendations from the relevant international organisations, e.g. ICRP, IAEA, UNSCEAR and WHO. The appropriate application of the optimisation principle in a remediation strategy, and its practical implementation, requires a balance of all factors that influence the situation, with the aim of obtaining the maximum benefit for the health and safety of the people affected. These facts have to be considered in communication with the public, in order to achieve a more realistic perception of radiation and related risks among the population. The Government should strengthen its efforts to explain to the public that an additional individual dose of 1 mSv per year is a long-term goal, and that it cannot be achieved in a short time, e.g. solely by decontamination work. A step-by-step approach should be taken towards achieving this long-term goal. The benefits of this strategy, which would allow resources to be reallocated to the recovery of essential infrastructure to enhance living conditions, should be carefully communicated to the public. The IAEA – and very likely also the international scientific community – is ready to support Japan in this challenging task.

(9) The start of lifting of evacuation orders associated with the completion of full-scale decontamination and other progresses, and follow-up decontamination

In April 2014, after the completion of full-scale decontamination in June 2013, the evacuation order was lifted on the Special Decontamination Area in Tamura City. On the other hand, in July 2014, the decontamination implementation plan was finally formulated in Futaba Town, where the formulation had been delayed the longest. As a result, formulations

[46]Source: IAEA "Final Report: The Follow-up IAEA International Mission on Remediation of Large Contaminated Areas Off-Site the Fukushima Daiichi Nuclear Power Plant" (January 23, 2014) (http://www.env.go.jp/press/file_view.php?serial=23734&hou_id=17656)

[47]Source: Excerpt from the draft translation (summary portion only) of the IAEA "Final Report: The Follow-up IAEA International Mission on Remediation of Large Contaminated Areas Off-Site the Fukushima Daiichi Nuclear Power Plant " (January 23, 2014)

of the decontamination plans in all municipalities in the Special Decontamination Area were completed (except areas where it was expected that residents will face difficulties in returning for a long time), and decontamination and measures toward the lifting of the evacuation order have been implemented.

The effects of the decontamination operations are reviewed by the post-monitoring to be conducted at six to twelve months after the initial decontamination operations. If there are places with erosion of effectiveness of decontamination, the investigation will be conducted to identify the cause as much as possible according to the individual situation. Then, by judging the rationality and feasibility, the follow-up decontamination operations will be implemented[48].

1.1.3. Overview of the change of the evacuation area designation

As mentioned in 1.1.2, the designation of the evacuation areas was changed several times (Figure 1-13). The outline of each evacuation area and the background to the modification of the designated areas are indicated here.

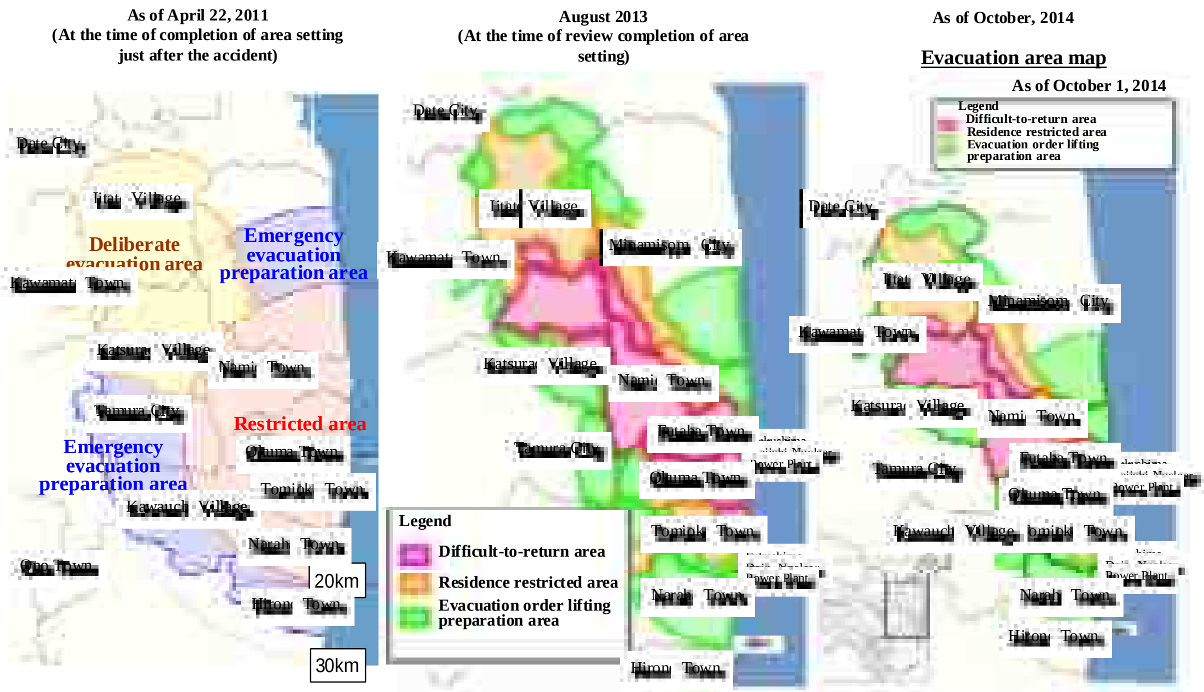


Figure 1-13 Change of the evacuation areas[49].

(1) Setting of the evacuation area and indoor evacuation area

In order to ensure the health and safety of the residents in the region around the FNPS, based on the situation of the reactors, the NERH directed the Fukushima Governor and the Mayors of other relevant municipalities to instruct their residents to evacuate or to shelter indoors, based on the "Act on Special Measures Concerning Nuclear Emergency Preparedness" (hereinafter referred to as the Nuclear Emergency Preparedness Act). (The directions on sheltering were lifted on April 22, 2011.)

[48] Source: The 11th Environmental Remediation Study Meeting Material: Follow-up decontamination (March 20, 2014)

[49] Source: Ministry of Environment (MOE), Evacuation area maps created based on the document of the “Government Nuclear Disaster Victims Life Support Team”

It should be noted that for the TEPCO's 2FNPS the risk of a serious accident occurrence decreased to a considerable degree in comparison with the situation on March 12, 2011 when the nuclear emergency had been declared. Therefore, the evacuation area which had been set as the area within the radius of 10 km from the 2FNPS was changed to the area within the radius of 8 km on April 21, 2011.

（2） Setting of the restricted area, deliberate evacuation area, and emergency evacuation preparation area

In order to ensure smooth evacuation of residents step-by-step, besides the restricted area and deliberate evacuation area, an emergency evacuation preparation area was set to deal with any future emergency.

1）Restricted area

In order to ensure the safety of the residents, the NERH announced to the Fukushima Governor and the Mayors of other relevant municipalities that it set the area within the radius of 20 km from TEPCO's 1FNPS as the restricted area based on the Nuclear Emergency Act (April 21, 2011). According to this instruction, nobody, except those who were engaged in the emergency response measures, including such public officials as firefighters, police officers, maritime officers, and self-defense force personnel, has an access to the area without the permission of the mayors after 00:00 on April 22, 2011.

2）Deliberate evacuation area

The NERH set the areas where the cumulative dose during the period of one year after the 1FNPS accident might reach 20 mSv as the "deliberate evacuation area," where evacuation to outside the area was required for residents within roughly 1 month, in consideration of the impact on their health (April 22, 2011).

3）Emergency evacuation preparation area

The NREH lifted the direction of indoor evacuation in the area within the radius of 20 km and 30 km from TEPCO's 1FNPS. On the other hand, under the accident situation which has not yet been stabilized, there were some areas where the need for such refuge could not be excluded in an emergency. The NERH designated such areas as the "emergency evacuation preparation area," where the residents are required to prepare for being able to evacuate indoors or to take refuge in an emergency (April 22, 2011).

（3） Rezoning through lifting and reviewing of former designations

The NERH announced the concept for the review of the evacuation area. The announcement stated the evacuation orders had substantial impact on the lives of residents and it would be appropriate to review the evacuation orders, once a significant change occurred in the situation, for example, the verification of safety of nuclear reactor facilities was made or the reduction of dose was confirmed on the basis of continued monitoring. It was decided that the evacuation area would be reviewed, revised and set as the new evacuation designated areas according to their perspectives of recovery and reconstruction, based on the results of radiation monitoring and the safety evaluation of the reactors and other factors,.

1）Lifting of the designation of emergency evacuation preparation area

Concerning the emergency evacuation-preparation area, which the NERH had designated between the radius of 20 km and 30 km from 1FNPS as the area where emergency responses such as evacuation might be requested in an emergency, the NERH decided the policy[50] (August 9, 2011) when to lift the designation The policy dictated that the designation should be lifted when the following conditions become foreseeable; safety evaluation of the nuclear power station, radiation monitoring results in detail in the area, and restoration of public services and infrastructures in the area.

Based on this policy, the relevant municipalities started the development of their own “recovery plans” according to their respective circumstances, in which the intentions of the residents were sufficiently reflected and cooperation with the prefecture was taken into account. Each plan included support of the residents’ smooth resettlement, reopening of public services such as schools and medical facilities, restoration of public infrastructure, and, decontamination of school grounds and parks. At the stage when the development of the individual plans was completed, the NERH decided to lift the designation of the emergency evacuation preparation area collectively and notified the relevant municipalities (September 30, 2011).

2）Reviewing of restricted area and evacuation area

Based on the recognition of termination of the accident at TEPCO’s 1FNPS and the reduction in the risk of radiation exposure, the NERH decided a policy to lift the designation of the restricted areas (the areas within the radius of 20 km from the nuclear power station) progressively, after making safety checks and completing the emergency restoration of infrastructures, and also after coordinating among the persons concerned for disaster prevention and crime prevention measures, etc. In addition, for the evacuation areas (the restricted areas within the radius of 20 km, and the deliberate evacuation areas located beyond the radius of 20 km from the nuclear power station), it was decided to review those areas and to classify them into three new areas cited below as shown in Figure 1-14, based on the radiation dose rates in those areas, and after having discussions with the persons concerned (December 26, 2011). It is noted that the various kinds of limitations were mitigated especially in the areas in which evacuation orders are being prepared for lifting (the evacuation order lifting preparation area) as shown in Table 1-2.

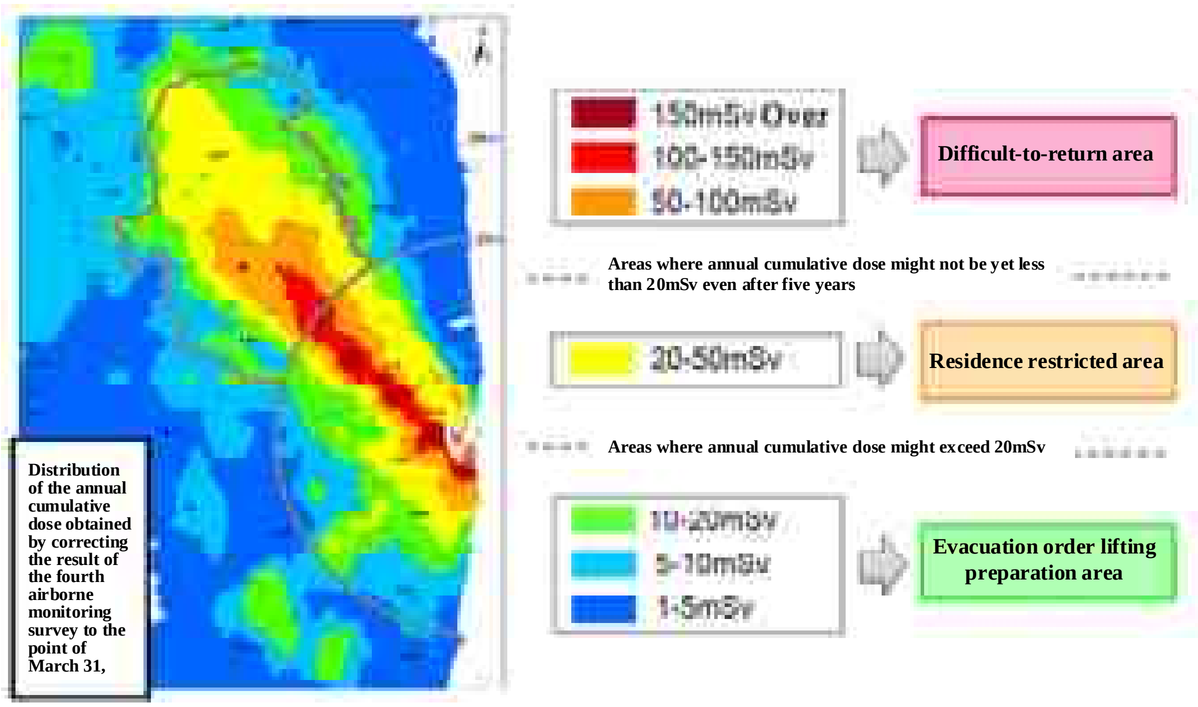


Figure 1-14 Review of the categories of evacuation areas into three designated areas based on the annual cumulative dose estimated from air dose[51].

[50]Source: Nuclear Emergency Response Headquarters (NERH), "The basic concept on the review of evacuation areas" (August 9, 2011)

[51]Source: Cabinet Office, "Review of the Evacuation Area" (October 2013) (Table 1-2 also the same source)

- Areas in which evacuation orders are being prepared for lifting (hereinafter referred to "Evacuation order lifting preparation area")

The evacuation order lifting preparation area refers to the area where it was confirmed that the annual cumulative dose would not exceed 20 mSv in the evacuation areas as of December 26, 2011. In those areas, the evacuation orders are still continued, but the supporting measures for recovery and reconstruction, such as decontamination, infrastructure restoration, employment promotion, should be taken quickly, and residents' return as soon as possible should be the aim.

It is noted that the evacuation orders will be lifted based on sufficient consultations with authorities of the prefecture and municipalities, and residents, under the condition that the infrastructures indispensable to daily life are almost restored, such as electricity, gas, water and sewerage systems, main transportation networks, and postal and communication services, and the life-related services including medical and nursing care, and at the stage in which the decontamination works mainly for the living environment of children are progressed sufficiently.

When lifting the evacuation order, the circumstances of each municipality have to be considered sufficiently. Therefore, the evacuation order should be lifted, not simultaneously in the whole area, but when each relevant municipality considers individually most appropriate. It can be also lifted step-by-step even within one municipality.

- Areas in which residents are not permitted to reside (hereinafter referred to as the "Residence restricted area")

The residence restricted area refers to the areas where the annual cumulative dose might exceed 20 mSv among the evacuation areas as of December 26, 2011, and that subsequently require continued refuge from the viewpoint of reducing the dose of the residents. In those areas, decontamination works and infrastructure restoration, etc. are carried out premeditatedly, aiming at the residents' return and reconstructing of the community in the future.

In addition, it has been decided to shift those areas to the "evacuation order lifting preparation area," when it is confirmed that the annual cumulative dose that inhabitants receive will not exceed for sure 20 mSv due to the decontamination works and the natural decay of radioactive materials.

- Areas where it is expected that the residents have difficulties in returning for a long time (hereinafter referred to as the "Difficult-to-return area")

The difficult-to-return area refers to the areas among the evacuation areas where the annual cumulative dose might not be yet less than 20 mSv even after five years, and exceeds 50 mSv as of December 26, 2011. According to the principle that the residence would be restricted in those areas for the future, it was decided that the designation of those areas would not be reviewed for five years. However, even in that case, according to contamination level due to radioactive materials in the future, the contents of the planning for reconstruction and restoration in related municipalities and the situation of their implementation, it was decided that the implementation of the review of those measures be considered.

It should be noted that the evacuation areas were reviewed and classified into three new designated areas using air dose rates basically as mentioned above. However, the distribution of air dose rates is complicated and is not uniform. Therefore, it was considered to be a basic principle from a practical viewpoint to avoid division of a community and to set the whole of the administrative section unit as one area within the newly classified areas, based on the dose level which occurs in most places within the administrative section unit.

Review of the evacuation areas was performed through coordination with the relevant local municipalities and residents. The designation of the area classification is closely related to the timing of return and the compensation. Therefore, there were some areas that needed much time for the adjustment. As a result, it was not until August 2013 that the review of all evacuation areas was completed.

Table 1-2 Mitigation of the limits due to the review of the evacuation areas

			Before review	After review: Difficult-to-return area	After review: Residence restricted area	After review: Evacuation order lifting preparation area	Change before and after the review of areas
Area control	Access to area		△ ＊Accessible in deliberate evacuation area	×	○	○	Accessible to home, etc. (excluding the difficult-to-return areas) (Notes 1)
Area control	Staying at home, etc.		×	×	×	×	–
Area control	Special staying		×	×	○	○	Allowed to stay at home during certain time-period(Notes 2)
Area control	"Staying for the preparations for the return to hometown"		×	×	△ (Notes3)	○	Permitted long-term staying if certain requirements are met.
Area control	Starting of new companies and business activities (company invitations, etc.)		×	×	△ (Notes4)	○ (Notes5)	Allowed to invite new companies
Area control	Reoperation of existing companies and businesses		×	×	△ (Notes4)	○ (Notes5)	Permitted reoperation of the existing businesses
Area control	Farming/Forestry		×	×	× (Notes6)	○ (Notes6)	Permitted restarting in a part of the evacuation areas
Reconstruction restoration businesses	Budget	Living environment improvement businesses	×	○ (Notes7)	○ (Notes7)	○	Acceleration of reconstruction and restoration businesses
Reconstruction restoration businesses	Budget	Return and restoration acceleration business	—	○	○	○	Acceleration of reconstruction and restoration businesses
Reconstruction restoration businesses	Tax (for businesses)	Special depreciation, etc., or tax credits to capital investment	×	×	○	○	Realization of the treated well business environment (except for return difficult areas)
Reconstruction restoration businesses	Tax (for businesses)	Tax credit for salaries to employees	×	×	○	○	Realization of the treated well business environment (except for return difficult areas)

(Note 1) Allowed temporary access to the residence restricted areas and evacuation order lifting preparation areas within the extent that municipalities recognize this. A year-round open system (temporary access to those areas once every month (Except for January and April) on the day when inhabitants hope) is being conducted in Okuma Town, Tomioka Town, Namie Town and Futaba Town.

(Note 2) It is possible to stay overnight during a certain period of time, based on application to authorities of the municipalities and after the confirmation of the nuclear disaster site headquarters. The total number of residents to stay overnight was 1,870 in New Year, Golden Week and Spring and Autumn Equinox Festivals (implemented municipalities: Kawauchi Village, Tamura City, Minami-soma City, Iitate Village, Katsurao Village and Kawamata Town).

(Note 3) In principle, the long-term staying applies to the evacuation order lifting preparation areas. Even in residence restricted areas, if the requirements are met, on the basis of consultation with the chiefs of municipalities and the head of nuclear disaster site response headquarters, long-term staying is permitted.

(Note 4) For the businesses that are indispensable in the restoration and reconstruction and recognized exceptionally, and the businesses that are not intended for residents (financial institutions, waste disposal treatment facilities, gas stations, manufacturing industries, etc.), it is possible to start the business operations after passing through the predetermined procedures.

(Note 5) As a general rule, the starting of the business to target the residents is impossible. However, for hospitals, welfare nursing facilities, restaurant businesses, retail trade and services, etc., the starting of the preparation works for implementation of businesses such as new construction and repair of facilities, receiving of materials and equipment, and inventory control, is possible.

(Note 6) Farming in the evacuation order lifting preparation area can be restarted based on the planting restrictions of rice and the status of decontamination. On the other hand, in the residence restricted areas, it is possible to carry out the maintenance and management of agricultural lands. It is also possible to carry out the planting demonstration projects etc., aiming at restart of farming in those areas, which are performed under the participation of public organizations of municipalities.

(Note 7) Living environment improvement businesses are limited only if those are deemed necessary for reconstruction and restoration toward the designation of the evacuation order lifting preparation area.

1.1.4. Outline of the Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District-Off the Pacific Ocean Earthquake that Occurred on March 11, 2011

（1） **Act on Special Measures**

1）The point of the Act on Special Measures

This Act was established to address the urgent issue of reducing promptly the impact of environmental contamination on human health and the living environment caused by radioactive materials, which had been released by the nuclear power plant accident associated with the Great East Japan Earthquake. It defines that the basic principles regarding the handling of the environment pollution caused by radioactive materials are determined in a cabinet meeting, and that the monitoring and measurement are carried out to determine the status of the environmental contamination by accident-derived radioactive materials. It also sets the matters relating to the disposal of wastes and the matters on measures for decontamination of soil, etc. contaminated by radioactive materials.

2）The Basic Principles under the Act

The Basic Principles under the Act provide a decontamination framework and were approved in the Cabinet meeting on November 11, 2011.
The following goals have been established in the Basic Principles.

- The areas where the annual additional exposure dose exceeds 20 mSv are aimed to be reduced in size step-by-step but as quickly as possible. However, it is necessary to note that a long-term approach is required for the areas where the radiation exposure dose is particularly high.
  The specific decontamination goals in these areas shall be set in the future based on the effect of decontamination measures of soil and wastes, the results of demonstration model projects and other development.
- For the areas where the annual additional exposure dose is below 20 mSv, the following goals are set.
  - ✓ The annual additional exposure dose decreases to 1 mSv/y or less in the long-term.
  - ✓ The annual additional exposure dose of the general public is reduced by about 50% by the end of August 2013 as compared with that at the end of August 2011, by including physical attenuation of radioactive materials and other factors..
  - ✓ It is important to restore the environment where children can live without fear. Therefore, the goal is set to reduce the annual additional exposure dose of children by about 60% by the end of August 2013 as compared with that at the end of August 2011, by decontaminating their living environment such as schools and parks in high priority and including physical attenuation of radioactive materials..

These goals will be reviewed appropriately based on the effects of measures of the decontamination of soil, etc.

In addition, for the Special Decontamination Area excluding the areas with particularly high additional exposure dose, the schedule to complete the decontamination in those areas in approximately two years was shown; "by the end of March 2014, measures for the decontamination of soil, etc., are carried out in residences, offices, buildings of public facilities, roads, farmlands, forests around the living space, etc., and soil removed by decontamination works is conveyed to the properly managed temporary storage sites one after another".
Further, for the areas with particularly high additional exposure dose, it was indicated that the National Government should implement demonstration model projects first.

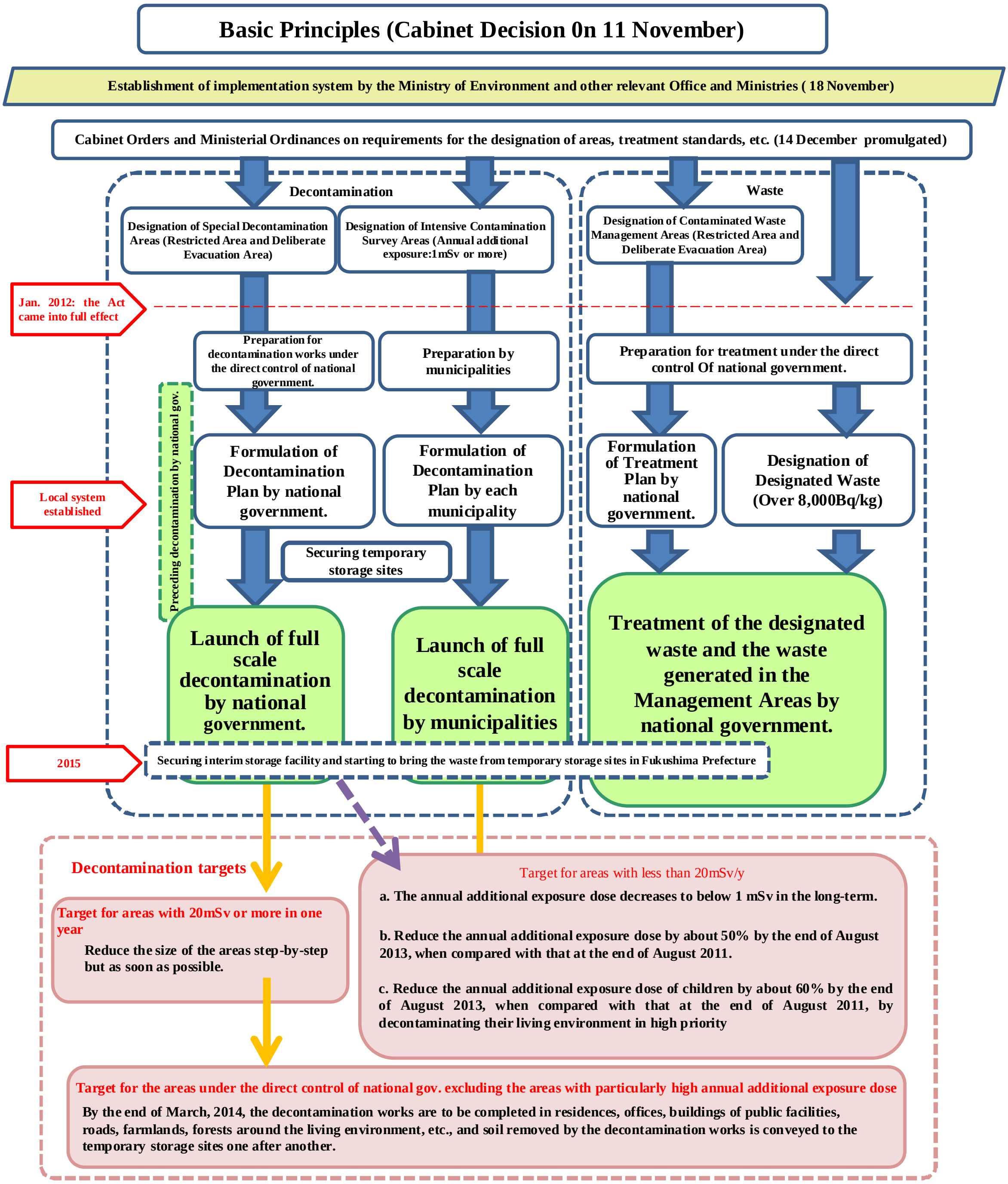


Figure 1-15 Outline of the Implementation of the Act on Special Measures[52].

（2） Urgent implementation basic policy on decontamination

As indicated in 1.1.2.(4) 1), prior to the promulgation of the Act on Special Measures, the "Urgent Implementation Basic Policy on Decontamination" was announced on August 26, 2011 by the NERH. In it, the following five items were defined as the provisional targets in implementing the decontamination.

[52] Document of Ministry of the Environment

(i) Based on the 2007 basic recommendations of the International Commission on Radiological Protection (ICRP) and the “basic concept” of the Japanese Nuclear Safety Commission, the areas with the situation of emergency radiation exposure (the annual additional exposure dose exceeds currently 20 mSv) are aimed to be reduced in size step-by-step but as quickly as possible.

(ii) For the areas with the situation of existig exposure (the areas where the annual additional exposure dose is 20 mSv/y or less), the aim is to reduce the annual additional exposure dose to 1 mSv/y or less in the long term.

(iii) As a specific target of decontamination implementation in the areas contaminated by radioactive materials, it is aimed that the estimated annual exposure dose of the general public be reduced by about 50% in two years.
According to the NERH provisional estimates, the estimated annual exposure dose after two years will be reduced by about 40% compared with the estimated annual exposure dose at present, by physical attenuation of radioactive materials and by natural factors such as wind and rain (weathering effect).
By reducing at least approximately 10% of the exposure dose by decontamination works, the above target of 50% reduction of the exposure dose will be achieved. In addition, further reduction of exposure dose will be pursued.

(iv) It is important restore the environment where children who are more susceptible to radiation than adults can live in peace as before. Thus, it is aimed that the estimated annual exposure dose of children be reduced by about 60% in two years through thorough decontamination works in their living environment such as schools and parks.
According to the NERH provisional estimates, the estimated annual exposure dose of children after two years will be reduced by about 40% compared with the estimated annual exposure dose at present, by physical attenuation of radioactive materials and by natural factors such as wind and rain (weathering effect).
By reducing at least approximately 20% of the exposure dose by decontamination works, the above target of 60% reduction of the exposure dose will be achieved. In addition, further reduction of exposure dose will be pursued.

(v) The targets mentioned above are the provisional targets being set based on limited information in order to urgently implement the decontamination works. Those should be examined and reviewed on a timely basis through detailed monitoring and accumulation of data, survey of actual exposure dose of children, and decontamination demonstration model projects.

In addition, the "Urgent Implementation Basic Policy on Decontamination" mentioned that for the achievement of these provisional targets, the National Government would continuously provide technical information ("a technical catalogue") necessary for the decontamination works, including effective decontamination methods, costs, precautions to make, which would be obtained through the demonstration model projects and the approach how to proceed with decontamination of each area depending on the difference in dose. The following four points were mentioned as the methods for "treatment of soil, etc. produced by decontamination works".

(i) The treatment of soil generated as a result of decontamination works, and rice straw, compost and debris that exist in the region, are indispensable for the implementation of smooth and quick decontamination works.
(ii) For treating such soil and wastes, the National Government takes responsibility for securing of their disposal sites where long-term management is required, and ensuring their safety. The National Government would publish a road map for the construction as quickly as possible.

(iii) However, in order to take these fundamental measures, time for securing and development of disposal sites of a certain size will be required. If we wait until such disposal sites are ready, it might delay quick decontamination.
(iv) Therefore, it is realistic for the time being that soil and wastes generated as a result of decontamination works are stored in temporary storage sites in each municipality or community. The National Government should continue all possible efforts to support municipalities in financial and technical aspects.

The Basic Principles of the Act on Special Measures shown in 1.1.4 (1) 2), are intended to take over the "Urgent Implementation Basic Policy on Decontamination."

（3） Prevention of radiation hazards due to decontamination works

The MHLW enforced the Ionizing Radiation Ordinance for Decontamination” on January 1, 2012, as a measure to reduce the radiation exposure dose of workers who were engaged in such works as decontamination works (hereinafter referred to as "decontamination workers").

Then, in July 1, 2012, the Ionizing Radiation Ordinance for Decontamination was revised to expand the applicable works in order to include the prevention of radiation hazards to the workers who were engaged in restoration/reconstruction and related works.

The main features of the Ionizing Radiation Ordinance for Decontamination are given below. The Ordinance is applied to the business operators for decontamination or works under a designated dose rate, their employees engaged in decontamination or works, under a designated dose rate.

(1) Basic principles of prevention of radiation hazards
(2) Limits and measurement of dose
(3) Measures concerning the implementation of decontamination and related works
(4) Prevention of contamination
(5) Special education, medical examinations, and others

Further, the MHLW developed the following two guidelines in order to enable business operators and their workers to perform decontamination related works in accordance with the Ionizing Radiation Ordinance for Decontamination.

- Guidelines for the prevention of radiation hazards of workers engaged in decontamination works, etc.
- Guidelines for the prevention of radiation hazards of workers engaged in works under a designated dose rate

These guidelines specify the items such as protection measures, medical examination offices and others.

1.1.5. Overview of the Special Decontamination Areas

（1） Requirements and designated situations for the Special Decontamination Area

The Special Decontamination Area is specified according to the Act on Special Measures as the area where the decontamination plans are developed by the MOE and the decontamination work is conducted under the direct jurisdiction of the National Government. It basically corresponds to the areas that were the restricted area within the 20 km radius from the TEPCO 1FNPS and the areas that were the deliberate evacuation area where the cumulative exposure dose for one year after the accident might exceed 20 mSv.

Specifically, as shown in Figure 1-16, the whole area of Naraha Town, Tomioka Town, Okuma Town, Futaba Town, Namie Town, Katsurao Village and Iitate Village, and the areas that were restricted areas or deliberate evacuation areas in Tamura City, Minami-soma City, Kawamata Town, and Kawauchi Village correspond to the Special Decontamination Area.

Figure 1-16 Special Decontamination Area[53].

(2) Structure of the decontamination works in the Special Decontamination Area

The decontamination for the Special Decontamination Area was scheduled based on the following basic policies. As shown in Figure 1-17, the decontamination implementation plans were developed at first by the Minister of the Environment. Preliminary decontamination for municipality offices and infrastructure facilities were conducted, while model projects were conducted by the Cabinet Office and the MOE, and then, full-scale decontamination is performed. As shown in Figure 1-18, the decontamination works have to be advanced while obtaining the landowners' consents because it is necessary to enter people's property to conduct full-scale decontamination

It is also necessary to secure temporary storage sites because a large amount of removed soil and contaminated wastes are generated as the decontamination works progress.

[53]Source: Ministry of the Environment (MOE), "Request for the cooperation for decontamination works" (February, 2012)

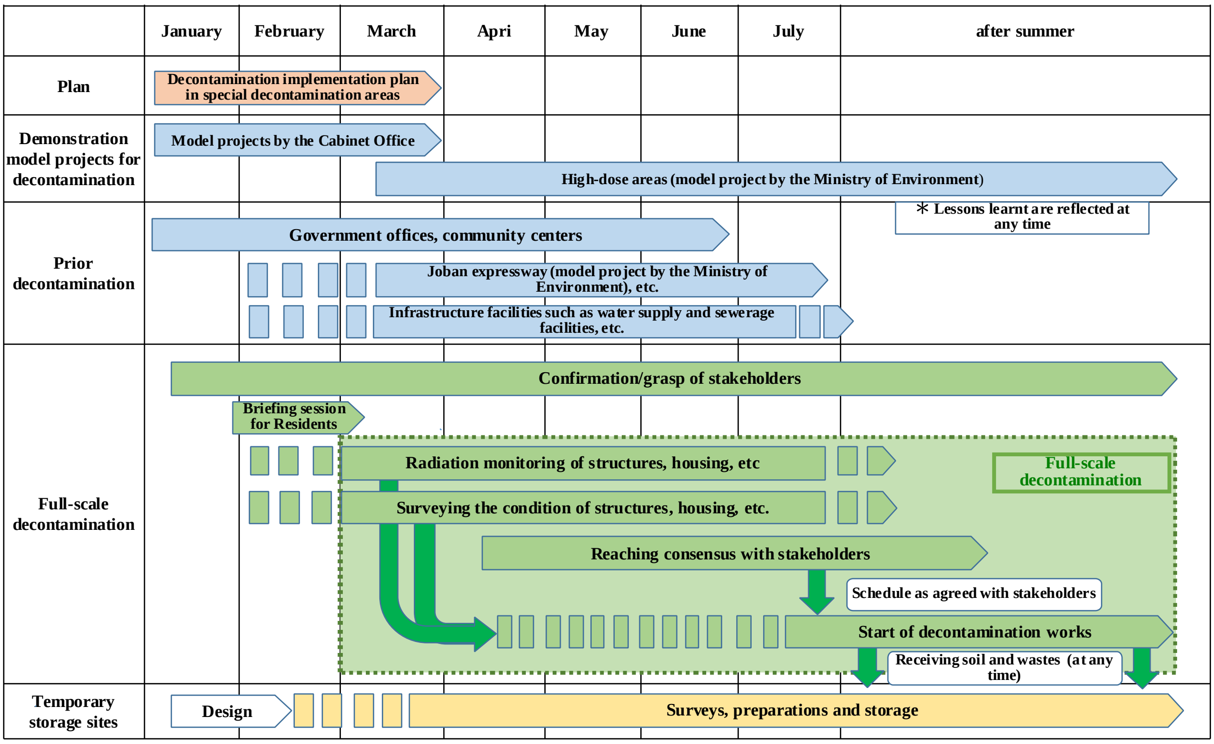


Figure 1-17 The short-term decontamination roadmap for Special Decontamination Area[54].

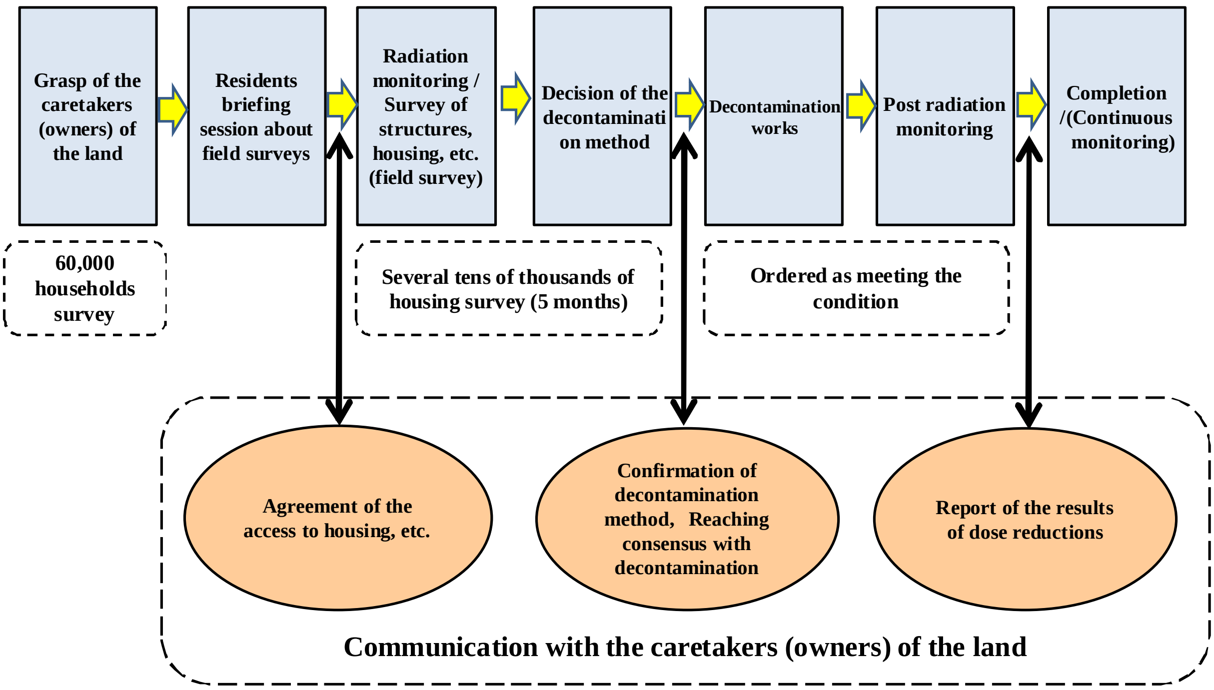


Figure 1-18 Flow chart of the decontamination steps.

[54]Source: Ministry of the Environment (MOE), "Decontamination Policy for Special Decontamination Areas (Decontamination Roadmap)" (January 26, 2012)(Figure 1-18 through Figure 1-20)

In addition, the Special Decontamination Area is classified into three areas depending on the level of exposure doses. Decontamination is due to start from the areas of the low exposure dose level, as shown in Figure 1-19, because the difficulty differs depending on radiation levels. The targets of decontamination in each area are as shown in Figure 1-20.

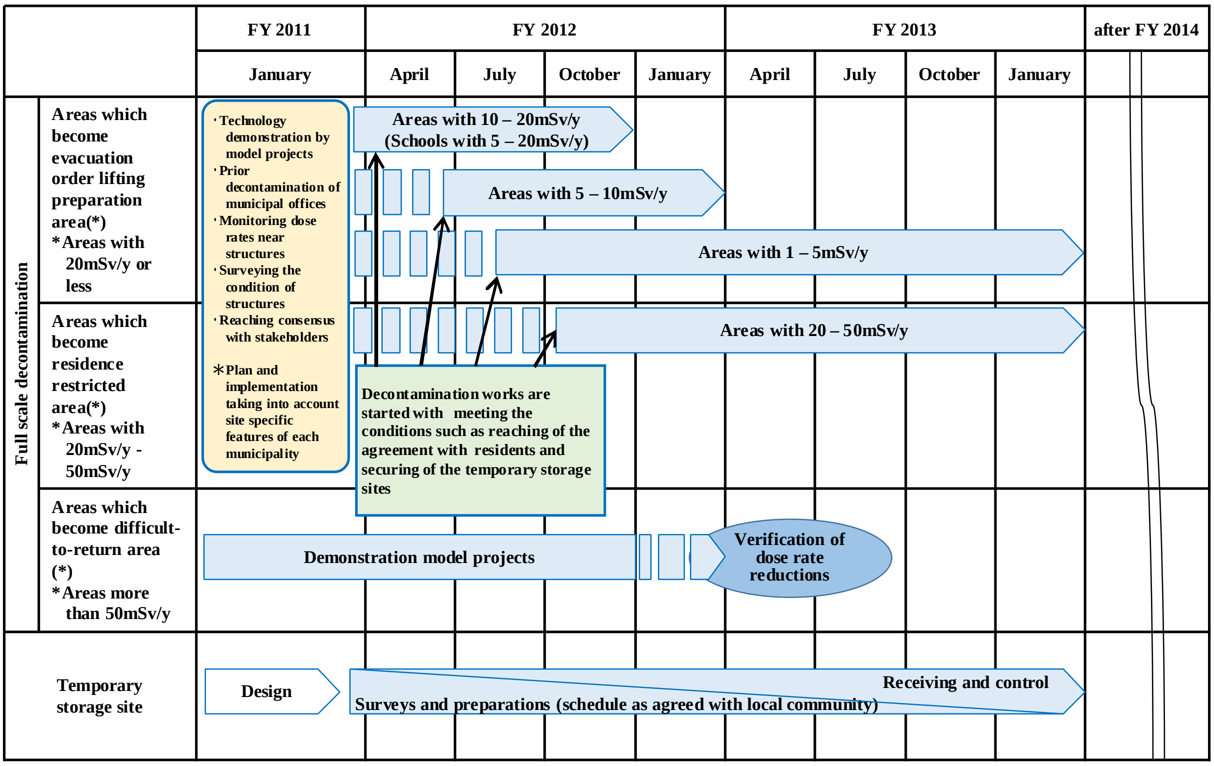


Figure 1-19 Decontamination roadmap for each new evacuation order area.

○By around the end of this fiscal year, decontamination implementation plan for special decontamination areas will be developed. Based on the plan, full-scale decontamination works should be performed.

○ Evacuation areas will be reviewed and classified into three new evacuation areas based on the level of air dose rate, and decontamination will be implemented in cooperation with the perspectives of recovery and reconstruction.

○ The prospects for securing of the temporary storage sites, and the aspects of smooth securing of workers must be considered in the plan.

○ Model projects and prior decontamination are carried out parallel. The knowledge obtained through them is reflected appropriately .

Policy for full-scale decontamination

Areas which become evacuation order lifting preparation area(*) *Areas with 20mSv/y or less

- By around the end of 2012, aiming for the decontamination of the areas with 10 ~ 20mSv / y (Schools, etc. with 5 – 20mSv/y(1- 4μSv/h))
- By around the end of March, 2013, aiming for the decontamination of the areas with 5 ~ 10mSv / y.
- By around the end of March, 2014, aiming for the decontamination of the areas with 1 ~ 5mSv / y.
- Specific targets in the areas are reflected in the plan, taking also into account the results of the model projects.
- Aiming to less than 10mSv / y for the areas with 10mSv / y or more for the time being. Aiming at 1μSv/h or less for schools, which is a criteria of the reopening of the schools.

Areas which become residence restricted area(*) *Areas with 20mSv/y - 50mSv/y

- Aiming at decontamination from FY2012 to FY2013.
- Aiming at the reduction of the size of the areas step-by-step but as soon as possible.

Areas which become difficult-to-return area (*) *Areas more than 50mSv/y

- Carrying out model projects for the time being.

Implementation policies and targets of the specific decontamination for each municipality are developed flexibly in coordination with stakeholders.

Main steps of the full-scale decontamination

①Grasp of the caretakers (owners) of the land to be decontaminated
②Briefing session for Residents
③Agreement of the access to housing, etc.
④Radiation monitoring/Surveying the condition of structures, housing, etc.
⑤Reaching consensus for decontamination with caretakers
⑥Implementation of decontamination works

⇨ **The development of the contents of this road map is planned and is utilized** in planning and project implementation **in future**

Figure 1-20 Points for the policy on the decontamination in the Special Decontamination Area.

Along with these decontamination framework in the Special Decontamination Area, the MOE carried out detailed monitoring from November 7, 2011 through February 28, 2012, in the areas where the National Government should perform decontamination, and the air dose rate distribution was clarified to some extent based on the measurement results.

The Government also carried out decontamination model projects (see 1.1.6 for details), collected knowledge about the decontamination, and then developed the common specifications of decontamination works ("Common Specifications") for the National Government to order decontamination works. Furthermore, the MOE held residents' briefing sessions prior to performing preliminary decontamination works, and acquired the agreement of the residents before carrying out major decontamination works. At the stage when preparations for ordering of the decontamination works had been completed, the MOE ordered decontamination works using the Common Specifications for decontamination works.

It should be noted that not only the provision of education to decontamination workers but also the proper management of the decontamination works are important because of the large-scale of the decontamination works. Thus, various efforts were being taken for decontamination works (See Chapter 4 for details).

(3) Review of decontamination implementation plans in the Special Decontamination Area

In the middle of fiscal year 2013 that is the last fiscal year of the original decontamination work period in Special Decontamination Areas, the MOE performed the "comprehensive check and review of the progress of decontamination works" (those findings were announced on September 10, 2013). The MOE discussed future decontamination plans with each municipality based on these results, and revised the decontamination implementation plans in the Special Decontamination Area to more realistic ones based on

Article 29, Clause 1 of the Act on Special Measures,. The outline is indicated below.

1）Outline of the comprehensive check and review

- The original target schedule, in which all the decontamination works had been planned to be completed and the wastes and soil to be transferred to temporary storage sites without exception within two years (by the end of March, 2014), should be revised to allow a flexible decontamination schedule in accordance with the situation of each municipality and progress of restoration.
- At that time, the measures to accelerate decontamination and to progress smoothly should be taken, and decontamination plans should be reviewed flexibly according to the progress of reconstruction.
- In Tamura City, decontamination works were completed in accordance with the decontamination implementation plan. In Naraha Village, Kawauchi Village and Okuma Town, decontamination works are aimed at completion in the fiscal year 2013 in accordance with the current plans and schedules. For Minami-soma City, Iitate Village, Kawamata Town, Katsurao Village, Namie Town and Tomioka Town, the MOE continues to coordinate planning with each municipality and will revise the current plans and schedule of works within the year. For Futaba Town, the development of the decontamination plan will be continued in coordination with reconstruction measures and the situation of the town.

2）Overview of the review of the plan

- For Minami-soma City, Iitate Village, Kawamata Town, Katsurao Village, Namie Town, and Tomioka Town, the comprehensive check and review in September decided to revise their decontamination plans by around the end of 2013. The revised realistic schedules are to be established through the consultation with each community concerned in view of current situations.
- Priority is to be placed on the decontamination of residential land and its neighborhood which is important for the residents' return. The implementation schedules of the decontamination works in each of the municipalities are shown in Table 1-3.
- Infrastructures, such as water supply, sewage systems and major roads should be decontaminated in advance in line with the progress of reconstruction activities by coordinating with related organizations.
- In implementing the projects, measures shall be taken to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible. The project schedules shall be thoroughly managed and the progress of the decontamination works shall be made transparent.
- Based on these, the decontamination plans in the subject six municipalities have been revised.

Table 1-3 Revised decontamination schedules[55]

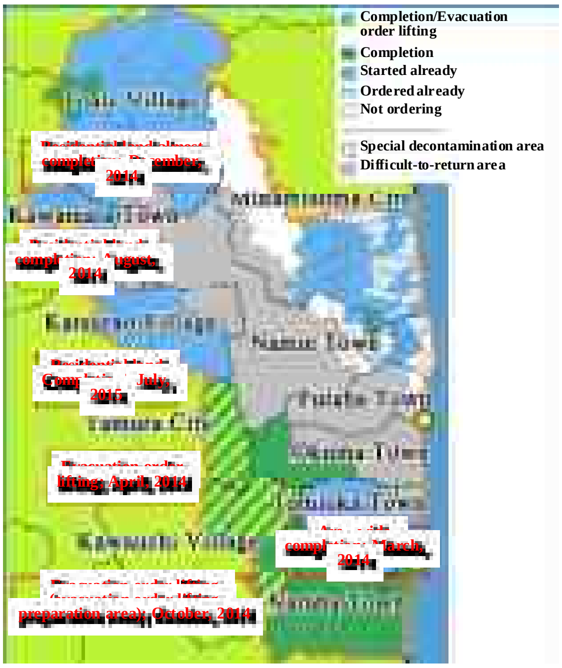
Minami-soma City	• The decontamination of residential land and its neighborhood is prioritized, aiming to be completed in the fiscal year 2015. • The decontamination works of other places aim to be completed in the fiscal year 2016. Furthermore, efforts are made to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible.
Iitate Village	• The decontamination of residential land and its neighborhood is prioritized, aiming to be completed in the fiscal year 2014. Furthermore, efforts are made to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible, aiming at the completion by the end of the year 2014. • The decontamination works of other places aim to be completed in the fiscal year 2016. Furthermore, efforts are made to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible, aiming at the completion by the end of the year 2016.
Kawamata Town	• The decontamination of residential land and its neighborhood is prioritized, aiming to be completed in the fiscal year 2014. Furthermore, efforts are made to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible, aiming at the completion in the summer of 2014. • The decontamination works of other places aim to be completed in the fiscal year 2015. Furthermore, efforts are made to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible, aiming at the completion by the end of the year 2015.
Katsurao Village	• The decontamination of residential land and its neighborhood is prioritized, aiming to be completed in the fiscal year 2014. Furthermore, efforts are made to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible, aiming at the completion in the summer of 2014. • The decontamination works of other places aim to be completed in the fiscal year 2015. Furthermore, efforts are made to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible, aiming at the completion by the end of the year 2015.
Namie Town	• The area-wide decontamination in the decontamination designated areas except for the tsunami disaster areas (Minamitanashio, Ukedokita, Ukedominami, Nakahama, Morotake) is prioritized, aiming to be completed in the fiscal year 2015. • While taking into consideration the treatment status of disaster wastes in the tsunami disaster areas, the decontamination of residential land and its neighborhood is prioritized, aiming to be completed in the fiscal year 2015. The decontamination works of other places aim to be completed in the fiscal year 2016. Furthermore, efforts are made to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible.
Tomioka Town	• The decontamination of residential land and its neighborhood is prioritized, aiming to be completed in the fiscal year 2015. • The decontamination works of other places aim to be completed in the fiscal year 2016. Furthermore, efforts are made to accelerate and advance the decontamination more smoothly, and to shorten the work period to the extent possible.
Futaba Town	• Coordination shall be continued for the development of the decontamination plan, taking into account the results of model projects, picture of reconstruction plan, and the level of radiation dose, etc.

※For implementation of the decontamination works, developing the decontamination plan, securing the temporary storage sites, reaching agreement with land owners, and securing of workers are preconditions.

[55]Source: Ministry of the Environment (MOE), "Review of decontamination implementation plan in s" (December 2013)

(4) Progress of the decontamination in the Special Decontamination Area

Figure 1-21 shows the decontamination status in the Special Decontamination Area as of March 2015. Even in Futaba Town, where the schedule of decontamination works had been delayed, the decontamination implementation plan was developed and decontamination works are due to start soon. Meanwhile, in Tamura City and Kawauchi Town, decontamination works were completed, and all or part of the evacuation orders have been lifted.



Tamura City	Completion of area-wide decontamination works in June, 2013 Lifting of the evacuation order on April 1, 2014
Kawauchi Village	Completion of area-wide decontamination works in March, 2014 Lifting of the evacuation order in evacuation order lifting preparation area on October 1, 2014
Naraha Town	Completion of area-wide decontamination works in March, 2014
Okuma Town	Completion of area-wide decontamination works in March, 2014
Joban Expressway	Completion of decontamination works in June, 2013 (Opening between the Hirono IC - Joban Tomioka IC on February 22, 2014) (Opening between the Namie IC - Minamisoma IC on December 6, 2014) (Opening between the Namie IC - Joban Tomioka IC on March 1, 2015)
Katsurao Village	Completion of decontamination works for residential land in July, 2014 Aiming at the completion of the works for other places in the year 2015
Kawamata Town	Completion of decontamination works for residential land in August, 2014 Aiming at the completion of the works for other places in the year 2015
Iitate Village	Aiming at the completion of decontamination works for residential land in the fiscal year 2015 Aiming at the completion of the works for other places in the year 2016
Minamisouma City	Aiming at the completion of decontamination works for residential land in the fiscal year 2015 Aiming at the completion of the works for other places in the year 2016
Namie Town	Aiming at the completion of decontamination works for the areas except for the tsunami disaster areas in the fiscal year 2015 For the tsunami disaster areas, aiming at the completion of decontamination works for residential land in the fiscal year 2015 and at the completion of the works for other places in the fiscal year 2016
Tomioka Town	Aiming at the completion of decontamination works for residential land in the fiscal year 2015 Aiming at the completion of the works for other places in the year 2016
Futaba Town	Aiming at the completion of decontamination works in the fiscal year 2015

Figure 1-21 Overview of the progress of decontamination works under the direct control of the National Government (as of March 2015)[56].

[56] Source: Ministry of the Environment (MOE), Produced based on "Progress of decontamination works under direct control of the National Government (as of March 2015) (https://josen.env.go.jp/material/pdf/josen_gareki_progress_201503.pdf)(Table 1-4 and Table1-5 are based on the same source)

Table 1-4 Progress of decontamination works under the direct control of the National Government (1) (As of February 20, 2015)

		Decontamination areas Population (people) (total)	Size of decontamination (ha) (round)	Review of areas	Progress of decontamination (Other than the municipalities of the work completion; as of February 20, 2015)				Schedule		Evacuation order lifting
					Decontamination plan	Temporary storage sites	Agreement acquisition	Works	Residential land completion	Other places completion	
Area-wide completion;	Tamura city	400	500	H24/4	H24/4	secured already	Acquired	June, 2013 completion	FY2013 (already completed)		April, 20144
	Kawauchi village	400	500	H24/4	H24/4	secured already	Acquired	March, 2014 completion	FY2013 (already completed)		Evacuation order lifting preparation area; October, 2014
	Naraha town	7,700	2,100	H24/8	H24/4	secured already	Acquired	March, 2014 completion	FY2013 (already completed)		Undecided
	Okuma town	400	400	H24/12	H24/12	secured already	Acquired	March, 2014 completion	FY2013 (already completed)		Undecided
Residential land Completion	Katsurao village	1,400	1,700	H25/3	H24/9	secured already	Almost acquired	Working	2014 summer (already completed)	In 2015	Undecided
	Kawamata town	1,200	1,600	H25/8	H24/8	About 90 %	Almost acquired	Working	2014 summer (already completed)	In 2015	Undecided
	Iitate village	6,000	5,600	H24/7	H24/5	secured already	About 90 %	Working	In 2014 (almost completed)	In 2016	Undecided
Under working/preparations	Minami-soma city	13,300	6,100	H24/4	H24/4	About 80 %	About 70%	Working	FY2015	FY2016	Undecided
	Namie town	18,800	3,300	H25/4	H24/11	About 40 %	About 70%	Working	FY2015	FY2016	Undecided
	Tomioka town	11,300	2,800	H25/3	H25/6	secured already	About 90 %	Working	FY2015	FY2016	Undecided
	Futaba town	300	200	H25/5	H26/7	Adjusting	Preparing	Preparing	FY2015		Undecided

Table 1-5 Progress of decontamination works under the direct control of the National Government (2) (As of February 20, 2015) (unit :%)

As of 20th February, 2015	Tamura City		Naraha Town		Kawauchi Village		Iitate Village		Kawamata Town		Katsurao Village		Okuma Town		Minami-soma City		Tomioka Town		Namie Town	
	Implementation rate	Order rate	Implementation rate	Order rate	Implementation rate	Order rate	Implementation rate	Order rate	Implementation rate	Order rate	Implementation rate	Order rate	Implementation rate	Order rate	Implementation rate	Order rate	Implementation rate	Order rate	Implementation rate	Order rate
Residential land	100	100	100	100	100	100	96	100	100	100	100	100	100	100	7	99.9	17	100	11	48
Farmland	100	100	100	100	100	100	25	100	18	100	68	100	100	100	8	65	5	100	13	35
Forest	100	100	100	100	100	100	38	100	56	100	99.9	100	100	100	34	79	28	100	14	43
Road	100	100	100	100	100	100	24	100	4	100	32	100	100	100	2	65	61	100	20	46

Note 1) Implementation rate is the percentage of the sizeof a completed series of decontamination works (weeding, sediment removal, washing, etc.), to the size of decontamination objects in each municipality.
Note 2) The order rate is the percentage of the contracted size to the size of decontamination objects in each municipality.
Note 3) Size of decontamination objects, ordering size, and the size that ordering acts have been finished may be changed with future surveys.

1.1.6. Overview of the demonstration model projects for decontamination

This section excerpts the outline of the report on the demonstration model projects for decontamination prepared by the Cabinet Office[57], which was positioned in the decontamination plans in the Special Decontamination Area indicated in 1.1.5.(1).

Through these projects, knowledge and decontamination technologies were confirmed. In particular, the following points were seen: the importance of monitoring to prevent any hot spot from being overlooked; the importance of such obvious work environment preparations as procurement and supply of decontamination-related goods including the securement of water supplies to push forward decontamination works; the impact of winter weather on decontamination works; implementing effective measures to maintain the quality of large-scale decontamination works; considering the possibility of re-contamination; having effective strategies to prevent recontamination; and having effective measures to reduce the volume of wastes. Moreover, it was also necessary to understand the anxiety of residents to decontamination works and to make sure radiation protection for decontamination workers.

The results obtained in these projects are shown in the following (3) (4), and particularly important findings are shown in (7).

（1） Objectives

The main objectives of the demonstration model projects for decontamination were to establish: the methods for efficient and effective decontamination; and the safety measures relating to radiation protection of workers for the areas mainly with high radiation exposure dose in which the annual additional exposure dose exceeds 20 mSv.

Specifically, an area of constant size for model project implementation was set in each of the 12 municipalities (Tamura City, Minami-soma City, Kawamata Town, Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village, Okuma Town, Namie Town, Katsurao Village, Iitate Village, and Futaba Town[58]) belonging to restricted areas and deliberate evacuation areas. In those areas, the verification and the evaluation of the decontamination effect were carried out for the decontamination methods and

[57] Source: Ministry of the Environment (MOE), "The overview report on the demonstration model projects for decontamination in restricted areas and deliberate evacuation areas (Final revision)" (June, 2012)
[58] Futaba Town had also been included in the implementation areas of the model projects at first. However the implementation has not been done because Futaba Town canceled the project.

technologies to be considered practical. And then, the data which would be utilized in the implementation of the future full-scale decontamination projects were acquired and prepared to be used immediately.

In addition, the results of these efforts were to be presented in the form of guidelines that could be used as the reference sources by the National Government and local governments, etc. when performing decontamination works.

(2) Implementation scheme and decontamination target areas

The target municipalities of the decontamination model projects for decontamination were divided into three groups of A, B and C by JAEA, which was commissioned from the National Government for the projects. In each group, Joint Ventures (JVs) performed the verification tests of decontamination technologies based on their proposals for the decontamination submitted responding to the public call for proposals by JAEA[59].

Target areas in each group and decontamination targets are shown in Table 1-6.

[59]For the decontamination model project, Group A, Group B, Group C have been implemented by Taisei JV, Kashima JV, and Obayashi JV, respectively.

Table 1-6 Target areas of the decontamination model projects in each municipality[60]

Groups/Municipalities		Target areas for the decontamination model projects	Decontamination target (Total about 209 ha) Main components/ features	Size
Group A	Minami-Soma City	Kanebusa Elementary School and surrounding area	Farmland, Building (Elementary School), Road, Forest, Residential land	approx. 13ha
	Kawamata Town	Sakashita area	Farmland, Road, Forest, Residential land	approx. 11ha
	Namie Town	Tsushima area	Building (Junior High School, etc.), Road, Forest, Residential land	approx. 5ha
		Gongendo area	Building (Station, Orbit, Library, etc.), Private house, Farmland, Road	approx. 13ha
	Iitate Village	Kusano area Base of "Patrol Team for the Entire Iitate-mura"	Building (Manufacture, Iitate home, etc.), Farmland, Private house, Residential land, Road, Forest	approx. 17ha
Group B	Tamura City	Jikenjo area	Farmland, Residential land, Road, Forest	approx. 15ha
	Katsurao Village	Katsurao Municipal Office and surrounding area	Farmland, Private house, Residential land, Road, Forest , Residential land, Road, Forest	approx. 6ha
	Tomioka Town	Yonomori Park	Building (Junior High School, Ground, etc.), Road (row of cherry blossom trees), Residential land, Forest	approx. 9ha
		Tomioka Daini Junior High School		approx. 3ha
	Futaba Town	—	—	—
Group C	Hirono Town	Chuo-dai/Nawashirogae area	Building (Government Office, Elementary /Junior High School, Ground),Residential land, Forest, Road	approx. 33ha
	Okuma Town	Okuma Municipal Office and surrounding area	Building (Government Office, Community Center, Park),Residential land, Road	approx. 6ha
		Ottozawa area	Farmland, Residential land, Road, Forest ,	approx. 17ha
	Naraha Town	Kamishigeoka area	Farmland, Residential land, Road, Forest	approx. 4ha
		Minami Industrial Complex	Building (Factory, etc.), Road	approx. 37ha
	Kawauchi Village	Kainosaka area	Farmland, Private house, Road, Forest	approx. 23ha

※1ha=10,000m^2

[60] Source: Ministry of the Environment(MOE), "The overview report on the demonstration model projects for decontamination in restricted areas and deliberate evacuation areas (Final revision)", (June, 2012)

（3） Overview of the results for decontamination targets

1）Residential land

A) Deposition status of radioactive cesium

- Large amount of radioactive cesium remain in the places where dust particles (soil) are carried by rainwater and accumulated (such as gutters and rain spouts).
- In addition, other than the places where rainwater accumulates, radioactive cesium tends to be deposited on and remain in the soil surface layer of residential gardens, concrete slabs on inclined surfaces, and asphalt surfaces.
- Surface contamination levels of vertical outer walls, on which dust particles carried by rainwater do not accumulate, are relatively low.
- As a result of investigating the deposition and retention status of radioactive cesium for different roof materials of houses (unglazed tiles, glaze tiles, cement roof tiles, galvanized iron), the largest amount of deposited radioactive cesium was for cement roof tiles. The deterioration of the surface condition of the cement tiles is considered to have influenced the deposition and retention.
- The amount of deposited radioactive cesium was relatively small for galvanized iron and slate.
- Moreover, radioactive cesium tended to be deposited and retained at specific spots on the roof.
  - ✓ Overlaying places of roof materials (such as tiles and galvanized iron)
  - ✓ Peeled portions of surface finishing (glazed or painted portions of roof tiles), rusted or corroded portions of roof materials
  - ✓ Dirty areas or tree sap adhering points on the roof.
  - ✓ The portions of tiles to prevent snow from sliding off of a roof, such as snow guards
- The dose rate of residential land was reduced overall by the decontamination works in the land. However it was found that the dose rate after the decontamination in the following places had the tendency to be slightly higher than other places. Those places were the regions where the implementation of decontamination works was difficult, such as narrow spaces, and around garden trees and other obstacles.

B) Decontamination methods and results

- High decontamination effect could be achieved by forcefully removing most of the deposits in gutters and then wiping off the remaining small deposits.
- It was observed that the decontamination effect on a roof varied according to the materials.
  - ✓ Brushing with a deck brush was effective for unglazed tiles and painted iron plates.
  - ✓ Manually wiping the surface was also effective for unglazed tiles.
  - ✓ Coating release agent had a relatively high decontamination effect compared to other methods for slate or cement roof tiles.
  - ✓ For cement roof tiles, decontamination effect was limited in all decontamination methods.
- Decontamination of the roof with a coating release agent provided a certain degree of decontamination and had a merit that it did not scatter the removed substances to the surroundings. However, it required covering the surface to be decontaminated with a protective material for 1-3 days and the temperature must be controlled inside the covering in winter. Therefore, its usability was limited and it was generally not practical.
- Decontamination of outer walls was carried out using the methods of "hand washing", "wiping off ", "high pressure water washing", and "brushing" for each material of tin, sash, glass, and wood. Even if the decontamination methods for outer walls were different, no big difference was confirmed in the surface contamination density after decontamination.
- Decontamination of gutters was performed using “wiping off” and “high-pressure water cleaning”. No significant difference was seen in their decontamination effects. “Wiping off” had better usability from the fact that contaminated wash water was not scattered to the surroundings.
- Decontamination of concrete (earthen floors) was carried out using high pressure water

washing. The effect of decontamination using high pressure water washing only was limited. When a relatively small area was targeted in the decontamination, surface cutting with the dust collection sander was effective for decontamination. However, it was not effective when a large area was targeted in decontamination, and it needed a dry surface condition. In addition, even if other methods such as metal brushes were used together with high pressure water washing, their effect on decontamination did not change.

- For gardens, the removal of gravel, etc. under rain gutters that had become hot spots had a significant effect for decontamination.
- It was found that air dose rates inside a building were reduced after the areas surrounding the building, and the degree of dose reduction was almost the same indoors and outdoors regardless of the material of the building (a concrete or a wooden building). Thus, in order to aim at reduction of indoor radiation level, decontamination of the area around the building is important.

2）Large buildings

A) Deposition status of radioactive cesium

- Large amounts of radioactive cesium remain in places where dust particles, which were deposited on large buildings, have been carried by rainwater and accumulated in certain areas (such as gutters and rainspouts). On the contrary, the amount of radioactive cesium was relatively small in the places where dust particles were just carried by rainwater and did not accumulate.
- It was confirmed that the radiation doses were higher in the places where dust particles were accumulated, or moss was growing, or in the drainage paths of rainwater, than those doses in their surrounding areas.
- Surface contamination levels of vertical walls of large buildings, on which dust particles carried by rainwater did not accumulate, tended to be low compared with those of concrete slabs on inclined surfaces or asphalt surfaces. On the other hand, contaminated vertical walls were also observed according to the movements of raindrops.

B) Decontamination methods and results

- The high-pressure water washing was effective for the decontamination of concrete roof with waterproofing.
- For the roof of concrete (mortar), decontamination effect was limited in all methods of “high pressure water washing (about 10 MPa)”, “high pressure water washing and brushing”, “nano-bubble washing”, and “special solution washing such as by oxygenated water”.
- The decontamination of outer walls was carried out using the methods of "wiping off " and "high pressure water washing" for each material of tin, sash, glass, and wood. Even if the decontamination methods of the outer walls were different, no big difference was confirmed in the surface contamination density after decontamination.
- “Wiping off” has better usability at a point from the fact that contaminated wash water is not scattered to the surroundings.
- It was found that the decontamination effect outside a building had influenced in reducing the air dose rates inside. This is considered to be due to reduced radiation from the radioactive materials outside which had been detected inside.

3）Farmland

A) Deposition status of radioactive cesium

- In most cases, 80% or more of the radioactive cesium inventory was present in the surface soil layer down to a depth of about 5 cm.
- It was observed that radioactive cesium penetration depth was deeper in the fields that had been plowed just before the accident.
- No remarkable difference was seen in the tendency for deposition and retention of radioactive cesium among rice fields, crop fields and orchards.

B) Decontamination methods and results

- An effective approach involves confirming the depth distribution of radioactive cesium; determining the practical depth and efficiency of dose reduction methods of mixed tillage, reversal tillage, interchanging topsoil with subsoil, or topsoil stripping; and performing the most effective reduction method.
- In addition, the magnitude of dose reduction efficiency was approximately in the order of "mixed tillage <reversal tillage < (or =) interchanging topsoil with subsoil   topsoil stripping".
  On the other hand, the amount of removed soil was in the order of "mixed tillage   reversal tillage   interchanging topsoil with subsoil << topsoil stripping".
- The effectiveness in dose reduction by reversal tillage or interchanging topsoil with subsoil, which does not produce soil for removal, was equivalent to that by topsoil stripping.

4) Roads

A) Deposition status of radioactive cesium

- Roads (paved) tended to have low air dose rates compared with soil surface of the surrounding farmland and bare ground, etc. This is believed due to the fact that radioactive materials deposited on the paved surface of the roads were washed away by rainfalls after the accident.
- Depth distribution of the surface contamination density of asphalt paved surfaces in high-dose areas has been measured. As a result, it became clear that most of the radioactive materials remained down to a depth around 2-3 mm from the surface for pavement face of dense grain-size, and down to a depth around 5 mm from the surface even for porous asphalt pavement (permeable pavements, etc.).
- From the relationship between the surface dose rate and surface contamination density, the value of the surface contamination density may be relatively high on some roads (paved surfaces). Radioactive cesium is unevenly distributed near the pavement surface in comparison with the soil surface of the surrounding farmland and bare ground. Thus, it is considered that the contribution to the surface contamination density by beta ray having a short range distance in solids is remarkable. This also corresponds to the distribution in the depth direction of the contamination density of radioactive materials.

B) Decontamination methods and results

- As decontamination methods for paved roads, "stripping-off" had a large efficiency of dose reduction, but generated larger quantities of removed wastes compared with other methods. Most of the inventory of radioactive materials was found to be present in a surface layer of asphalt, down to a depth of a few millimeters. Thus, it is possible to achieve a high decontamination effect, while minimizing the volume of wastes generated, by surface shaving off only this thickness.
- In comparison with "stripping-off (surface removal)", "washing" has the advantage that it does not generate wastes as in the case of surface removal or surface stripping-off. However, the efficiency of dose reduction is not high, and the collection and disposal of wash water are necessary.
- For asphalt paved surfaces, decontamination by "surface stripping-off or surface removal (water jet, shot blasting, TS cutting machine[61], etc.)" was more effective than "cleaning (dry road sweeping, etc.)" and "washing (high-pressure washing or use of vehicles for functional recovery, etc.)"
- "Surface stripping-off or surface removal" methods require machines and are difficult to be applied to areas in the vicinity of buildings and outer walls. Irregularities in the effect of dose reduction occurred for the roads with distorted and worn surfaces.

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[61] These were road surface cutting machines that scrape off asphalt paving or concrete paving by a rotary blade.

5) Parks and playing grounds

A) Deposition status of radioactive cesium

- The tendency was observed that more than 80% of the radioactive cesium deposited within the depth around 5 cm from the surface in most places.
- The tendency was strong that radioactive cesium deposited and remained in degraded rubber playground equipment and rusted metal playground equipment. On the other hand, the tendency that radioactive cesium deposited and remained in metal playground equipment with a smooth surface was weak.

B) Decontamination methods and results

- Wiping was effective in dose reduction for playground equipment with the smooth plastic surfaces. For metal playground equipment with rusted areas, cleaning with scrubbing brushes was effective for dose reduction, although it was limited.

6) Forests and trees

A) Deposition status of radioactive cesium

(Evergreen forests)

- The tendency was observed that the residual radioactive cesium was remaining higher in litter layers containing the fallen leaf layer which was formed newly during 2011
- It was observed that the amounts of residual radioactive cesium were small in the bark portions of tree trunks in comparison with other parts. It is thought that most of the radioactive cesium deposited in the leave and the branches and could not reach the trunk part.
- Radioactive concentration of fallen leaf layer formed by dropping of leaves which grew at the time of the accident (the surface layer that was formed by the newly fallen leaves during the year of the accident) was high compared with deciduous trees. It is thought that in evergreen trees, much more radioactive cesium deposited on the leaves, which grew at the time of the accident, compared with other parts.

(Deciduous forests)

- It was found that much radioactive cesium was depositing and remaining in the litter layer and outer bark of the trees. It is thought that this was because not many leaves had grown at the time of the accident.
- The amount of residual radioactive cesium has been compared between the fallen leaf layer which was formed during the year of the accident and the fallen leaf layer which had been formed before the accident under the fallen leaf layer during the year of the accident. As a result, the former (fresh layer) had a generally smaller quantity of radioactive cesium compared with the latter (older layer). This is also considered to be because not many leaves had grown at the time of the accident, most of the radioactive cesium that fell on deciduous trees was deposited on the ground surface under the trees, and then, the accident year's fallen leaf layer was formed on the contaminated ground surface.

B) Decontamination methods and results

- Implementing both "weeding" and "removal of the accident year's fallen leaf layer" may have (limited) effects of dose reduction in evergreen forests.
- On the contrary, in deciduous forests, surface contamination density was increased by implementing both "weeding" and "removal of the accident year's fallen leaf layer". It is considered that, at the time of the accident, radioactive cesium deposited on the ground surface; The ground surface was covered afterwards by new grasses which grew thickly and the accident year's fallen leaves without radioactive cesium contamination; and the radiation from the ground surface was shielded by them.
- It was observed that surface dose rate and surface contamination density were reduced to a

certain extent by "removing the litter layer" in addition to "weeding" and "removal of the accident year's fallen leaf layer" for both deciduous forests and evergreen forests. However, it is necessary to consider that removal of the litter layer may have impacts on forest ecosystems, such as changes in nutrient of soil.

- High-pressure water washing for trunks of trees with some barks peeled off but with no adverse effects on their growth had high decontamination effects.

(4) Outline of results for works associated with decontamination

1) Disposal of wash water

- Effluent criteria were able to be satisfied by using the combined processing methods of filtration, adsorption, and coagulation/sedimentation, according to the degree of contamination of wash water in each spot (including the stagnant water in side ditches) or stagnant (pond) water before the accident.

2) Volume reduction methods of removed wastes such as branches and leaves

- Crushing machines could reduce volume of branches and leaves while preventing scattering of dust with deposited radioactive materials to the surroundings by applying dust collection measures. However the volume of logs was not reduced so much, because logs were not so bulky even before crushing.
- High temperature incineration could achieve extremely large volume reduction of branches and leaves without spreading of the radioactive materials deposited on them together with the exhaust smoke to the outside. Furthermore, it was confirmed that cesium concentration in the exhaust gas was sufficiently lowered below the concentration limit of radioactive materials in air specified by the law when treating the flue gas with bag filters or HEPA filters.
- Low temperature incineration was lower in volume reduction ratios than high temperature incineration or crushing machines.

3) Generated amount of removed wastes

- Generated amount of removed wastes greatly depends on differences in the decontamination methods rather than the differences in annual cumulative dose of decontamination implementation areas.
  - ✓ If the decontamination methods such as "topsoil stripping", "weeding", "removal of fallen leaves, etc." are selected for decontamination works, larger amount of removed wastes is generated.
  - ✓ As shown in (3) 3), the effectiveness in dose reduction by "inversion tillage" or "interchanging topsoil with subsoil" is equivalent to that by "surface soil stripping-off". However, "inversion tillage" or " interchanging topsoil with subsoil" does not result in the generation of waste removed soil.
- More than 80% of radioactive materials can be reduced in most places by removing surface soil to approximately 5 cm, regardless of the level of annual cumulative dose and land-use classification. However, the thickness of the stripping that directly relates to the amount of generated soil to remove should be set in consideration of both the vertical distribution of radioactivity concentrations and the decontamination targets.
  - ✓ The vertical distribution of radioactive material concentrations in the ground has a tendency that the reduction rate of the concentration (the rate of concentration decrease per each 1 cm in depth) significantly decreases as it goes deeper (exponentially decreasing)
  - ✓ For example, when 80% of the radioactive materials are included in the top 5 cm of the ground and 90% in the top 8 cm, the additional dose reduction of 10% is expected by removing the additional layer of 3 cm below 5 cm deep in comparison with removing the top 5 cm for removing 80% of radioactive materials. However, the amount of removed objects would increase by 60%..

- ✓ Surface soil may have to be stripped off more deeply to lower the density of radioactive materials of the topsoil below the fixed absolute value in the areas with high annual cumulative dose.
- ✓ However, the concentration distribution of radioactive materials in the underground depth direction may be different from that of the demonstration model projects for decontamination implemented to date, depending on unevenness of the ground surface and other factors. Therefore, the concentration distribution of radioactive materials in the ground depth direction should be checked first before starting decontamination works, and then the stripping thickness to achieve the decontamination target needs to be determined.

4）Temporary storage sites/on-site storage sites

- When installing temporary storage sites and the like, the planned sites must be decontaminated in advance and appropriate shielding measures have to be taken after the wastes are loaded and emplaced. Therefore, air dose rates in temporary storage sites do not increase but rather decrease after loading and emplacement of wastes, regardless of the level of air dose rates of the sites before installation.
  - ✓ Air dose rates are also reduced by covering removed wastes with sandbags filled with uncontaminated soil.
  - ✓ When bringing the removed objects into the storage sites and placing them therein, the radiation influence from those with high surface dose rates can be reduced by placing them at the center of the site, and those with lower surface dose rates are placed around them. By doing so, the influence of radiation from the removed objects with high surface dose rates can be reduced by the shielding effect of the removed objects themselves.
- Types of temporary storage sites have to be selected based on the opinions of municipalities and residents, and taking into account topographical characteristics, land use situation, and available area of the target sites.
  - ✓ Aboveground storage is the easiest type for shipment of stored wastes to the Interim Storage Facility. On the other hand, when installing the storage sites on soft ground, it is necessary to improve the foundation.
  - ✓ Underground storage has the advantage that the soil for the shielding can be secured at the sites. On the other hand, it takes time to excavate the underground portion, and measures have to be taken, for instance, for stopping groundwater inflow.
  - ✓ For semi-underground storage, it is possible to increase the storage capacity even for a limited place of the sites. However, it takes time to excavate the underground portion. In addition, it is necessary to apply rainwater infiltration measures at the boundaries of the aboveground portion and the underground portion.

5）Radiation exposure dose control of decontamination workers

- Exposure doses of decontamination workers were studied for each decontamination target area. The workers in areas with higher air dose rates monitored before decontamination generally had higher exposure doses. Nevertheless, exposure doses of workers in the areas with annual cumulative dose less than 50 mSv and with appropriate measures for exposure control were well below the reference value of the exposure dose limit stipulated by laws and ordinances.
- On the other hand, exposure doses of workers in the areas exceeding the annual cumulative dose of 50 mSv may exceed the exposure dose limit stipulated by laws and ordinances, if they work continuously for five years in those areas. Therefore, in such cases, more stringent radiation control is required, such as optimizing the combination of decontamination methods and work procedures for dose reduction, and promoting the work efficiency by utilizing machines.

6）Costs for each decontamination method

- Costs required for the works using the decontamination methods which bring larger dose reduction effect tend to be higher.
- It should be noted that, as can be seen in the following cases, it is necessary to consider overall factors including costs, the volume of removed wastes to be generated, and workability in addition to the dose reduction effect, when selecting decontamination methods.
  - ✓ The case in which different decontamination methods with the same level effect of dose reduction have different features regarding costs, the generated amount of removed wastes, and workability.
  - ✓ The case in which different decontamination methods with the same level effect of dose reduction and cost requirements have different features of workability.

（5） Results of the implementation of area-wide decontamination works in demonstration model projects for decontamination

- Decontamination works were carried out in the areas where the radiation level before decontamination had been higher than the level to cause the annual cumulative dose of 20 mSv or more and below 30 mSv. The works cold reduce the radiation level to cause the annual cumulative dose below 20 mSv.
- Decontamination works were also carried out in the areas where the air dose rate before the works was higher than the level to cause the annual cumulative dose exceeding 40 mSv. After the works, the air dose rate could be reduced by around 40-60%. However, it was not possible to reduce the level to a level to enable the annual cumulative dose below 20 mSv.
- Decontamination work was carried out in Ottozawa area, Okuma Town, where the air dose rate before the works had been at the level to cause 300 mSv or more as the annual exposure dose. After the works, the air dose rate could be reduced more than 70% in farmland and residential places. However, the air dose rate was not able to be reduced to a level to achieve 50 mSv/year or less for the whole area.
- In some areas with lower air dose rates before decontamination, decontamination methods that do not generate much waste were tested. Although the amount of removed wastes was relatively small, the reduction in air dose rates was lower compared with the case in higher air dose rate areas.

（6） Guidance on decontamination works

The findings obtained in the demonstration model projects for decontamination are summarized in the form of guidance[62] and have been published for the following eight items.

- Guidance on obtaining informed consent (agreement acquisition) concerning the decontamination implementation areas, selection of temporary storage sites and their stakeholders
- Guidance on monitoring
- Guidance on decontamination works
- Guidance on preparation and maintenance for temporary storage sites/on-site storage sites
- Guidance on screening (contamination inspection)
- Guidance on the treatment of wastes generated by decontamination works
- Guidance on workers' occupational safety management
- Guidance on supervision for outsourcing companies

[62] Source: published on JAEA home page (http://fukushima.jaea.go.jp/initiatives/cat01/entry02.html)

(7) Important findings obtained in demonstration model projects for decontamination

1) Important findings obtained for establishment of the work environment

- In restricted areas, it is important to secure site offices and rest places which serve as bases in decontamination works and securing water for decontamination. If rest places are not secured in time, the limitation occurs in the length of working hours in which workers can work continuously. If water cannot be secured on site, it must be brought from outside the restricted areas. As the facilities for rest places and the like, it was effective to utilize public grounds and public facilities, because coordination with the persons concerned for their use could be made in a short period of time.
  Machinery and equipment to be used for decontamination works might be possible to procure on a, lease contract, but there were cases in which to bringing them into the restricted area was refused. When procuring them on a lease contract, it is necessary to provide sufficient information to the lease companies on the appropriate contamination inspection of the machinery and equipment, and the appropriate decontamination methods to apply when needed and other conditions, and to clear the concerns of these companies.
- Damage conditions of houses were investigated by outsourced specialty companies. The contents of the investigation were based upon a construction damage investigation of damage possibilities by decontamination works. The investigation did not include applicable environmental conditions and construction constraints for decontamination works, for example, investigations to determine whether it was possible to set up scaffolding on roofs for the works were not included. Therefore, it will be an efficient approach in the damage survey of houses for the subsequent decontamination works, not only investigating the damage conditions, but also checking whether the houses are in such environmental conditions in which appropriate decontamination methods for the houses concerned can be applied technically, and whether there are concerns about construction constraints for decontamination works.
- For large-scale decontamination works, there may be many places where wash water is produced. Therefore, difficulty was foreseen to set up water treatment facilities in one place for a long term. For this reason, a water treatment system, such as a vehicle-mounted one, should be considered, which can move to the places where the wash water is generated.

2) Important findings obtained for monitoring

- Regarding the monitoring to locate hot spots, there were cases which caused the residents' complaint. Such cases occurred when the hot spots could not be located in the pre-monitoring stage and they were found later by the residents' own measurement after the decontamination works. Important knowledge obtained regarding monitoring is:
  - ✓ It is necessary to set the number of monitoring points per house in a flexible way, not to fix it at a certain number, in order to prevent overlooking of the necessary decontamination works.
  - ✓ In mesh measurements, the measurement in shorter pitches gives better accuracy, but the workload increases instead. For optimization, a combined use of back-pack type or buggy type instruments in mesh measurements was more effective than expanding the measurement pitches of mesh measurements for preventing the overlooking of hotspots.
  - ✓ For locating hotspots, it was effective to search for a place where the air dose rate was relatively higher than other places in the surrounding by the measurement device with shortened time constant for higher sensitivity. A two-dimensional dose rate distribution evaluation system, which combined a GPS device and a dosimeter, was an effective tool for locating hotspots because of its high spatial resolution, no requirement of high measuring skills, and less data variation of measurements, and less risks of overlooking hotspots.
- Risks of overlooking hotspots could be minimized by post-work monitoring by the work leaders as a means of work result management, in order to locate any spots with high dose rate or high surface contamination densitiesleft behind. So was for the soil and wastes to be removed.

3) Important findings obtained for the influence of winter weather on decontamination

- Generally in the snowfall, the measured radiation dose becomes lower due to the shielding effect of the snow on the ground. In the demonstration model projects for decontamination, the reduction effect of dose rate due to snow was evaluated quantitatively. As the result rough evaluation of dose rate has become feasible even when snow-covered.
- Machinery and equipment for decontamination may be subjected to freezing in midwinter and the working efficiency may be significantly affected. It has been recognized that anti freezing measures should be considered, by keeping them in shelter, for instance.
- Sometimes the soil solidifiers did not work for topsoil stripping during the winter because of low temperatures. In some other cases, the frozen layer of topsoil was stripped off up to the frozen depth at one time, thicker than the preset thickness to strip. The amount of removed objects thus increased. On the other hand, however, it has been recognized that the surface soil could be stripped off effectively by using road surface cutting machines.
- Following risks have been also recognized: Frozen top soil when stripped off or frozen soil for shielding may increase the amount of seepage water after they are transferred to the temporary storage sites; flexible container bags for shielding (hereinafter referred to as "flexible containers") may deform and subside; or the welded portion of impervious sheets may fail. Furthermore, risks of deformation of water collection boxes have been also noticed.

4) Important findings obtained for maintaining the quality of decontamination works

- A tendency was noticed in decontamination works that the decontamination effects varied depending on the work methods of individual workers. Particularly, in top soil stripping, soil was occasionally spilled during plowing regardless of hand work or machine work. This has been noticed as one of the causes for differences in the decontamination effects.
- When decontaminating by top soil stripping with the stripping thickness under control, grass roots in the actual soil surface impeded stripping off in the predetermined thickness, Sometimes it became necessary to remove grass roots and then to strip the topsoil off beyond the predetermined thicknesses. In the land with irregularities, it was also necessary to strip off thicker layers than the predetermined values. In order to reduce the deviation from the predetermined stripping thickness, prior rolling compaction has been effective.
- It has been found that both coagulating sedimentation method and filtration method had advantages and disadvantages for the treatment of recovered wash water. For example, for the coagulating sedimentation method, the device is simple and it is easy to use, but the process such as water removal from the sediment and solidification of the sediment is required. On the other hand, in the filtration method, residues are solid and it is easy to handle them. However, it takes time to complete the filtration, and measures such as the reverse washing because of blocking of the filter are required. In addition, while the coagulating sedimentation method is a batch process, the filtration method can be run continuously. It is difficult to recommend unconditionally which processing method can be used for recovered wash water. This is because the process to be used varies according to the properties of treated water and the required amount of processing. As a result, the use of the processing method according to the situation or the use of a combination of processing methods is effective for treating recovered wash water.

5) Important findings obtained for the prevention of re-contamination

- The places that had been decontaminated were distinguished using colored cones and other means, and furthermore measures were taken to prohibit entering those places at the time the decontamination works were being done. These actions were effective for the prevention of re-contamination.
- It should be noted that, in the demonstration model projects for decontamination, daily monitoring has been carrying out continuously at the fixed points, including the points where individual decontamination works had been completed. As a result, during the period

of around one month from the end of the decontamination works to the end of the projects, hardly any situations such as a dose rate increase after the completion of decontamination works have been observed. In other words, the influence of significant secondary contamination have not been seen.

6）Important findings obtained for the volume reduction of wastes

- Among flammable decontamination wastes, branches and leaves generated from forests and the undergrowth of weeds such as the bamboo grass were bulky when stored in flexible containers. Therefore, the filling efficiency of the flexible containers could not be increased. Incineration was a very effective treatment method because the volume reduction rate was high and spread of radioactive cesium was suppressed by installing filters for the exhaust gas. However, it is necessary to note that the equipment is relatively large-scale and the incineration ash must be handled.
- Wood crushers and wood chippers were effective processing devices. This was because their volume reduction rate was relatively high although it depended on the processing targets, and the equipment was not large in scale. However, when wood chippers were used, it was desirable to take measures such as laying dust sheets around the equipment because the scattering of small pieces of wood is expected.
- For volume reduction of undergrowth generated from vast grasslands, compression by an undergrowth accumulation machine attached to a tractor (roll baler) was regarded as an efficient method from the viewpoint of volume reduction rate and work efficiency, although the human power to accumulate undergrowth of weeds was required.
- Volume reduction by compressing dead leaves with a heavy loader vehicle and volume reduction by sucking off air in sealed bags with large vacuum cleaners that can be easily carried into fields were other measures.
- Soil stripped from farmland (especially pastures) and playgrounds, schoolyards, parks (especially lawn areas) included large numbers of plant roots. It is very effective from the viewpoint of control of the waste amounts that the stripped soil portions are separated into soil and flammables (plant roots). In order to separate in this way, twisters[63] and vibration sieve machines were used. This technique cannot be evaluated with a numerical value of separation rate because separation depends on what are included as the non-flammables (such as soil and stones) and what are included as the flammables (such as plant roots). The results of the separation tests of soil and plant roots were confirmed by visual inspection. For test conditions that were good, flammables such as many roots were not included in the separated soil. Therefore, it was possible to control the separated soil as non-flammables. Consequently, this method was considered to be effective from the viewpoint of waste management. When highly viscous soil was treated (clay), the soil could not be broken by the twister and therefore a large amount of soil was separated to the root side (flammables). Thus, it was also found that it is necessary to pay attention to the soil properties.
- Combination treatment method was considered, in which grass roots that have been separated by the twister were processed by low temperature incineration using a rotary dryer[64]. In this case, all the wastes that were left after burning could be treated as non-flammables.

7）Important findings obtained regarding the anxiety of residents

- From local residents, including the landowners, and local governments, there were many requests to report the progress of decontamination works and the effect of dose reduction by decontamination. It has been found to be important to respond to these requests politely. To promote decontamination works while building the relationship of mutual trust with local governments and local residents, it was important that information control be implemented

[63] Twister (rotary crushing mixer) (Machinery for crushing and mixing the soil with striking force of a chain rotating at high speed)

[64] Rotary (tumble) dryer (Machine for heating and drying the soil containing moisture in a rotating tube)

without exception to prevent release of personal information, while ensuring that the information on the details and the results of the works were offered regularly as far as possible.

- Many concerns were voiced from residents regarding downstream contamination by wash water. Downstream contamination by wash water was found to be one of the biggest causes of uneasiness. Therefore, when decontamination works were carried out using water, it was important to take outflow prevention measures such as providing weirs in roadside ditches where wash water flowed into. In the case of high-pressure water washing of houses and garden planting, it was possible to prevent secondary contamination by removing concrete facings and surface soil under the planting and near the house after high pressure water washing.

8) Important findings obtained for safety protection of the decontamination workers

- At the places where the levels of contamination were estimated to be especially low, it was considered at first that the wearing of sealed chemical protective clothing and a full-face mask was not always necessary, if post-work contamination checks of workers were thoroughly carried out. However, in the case of actual works, some workers could not feel relieved without wearing these protective items, and heavily equipped workers, who wore both the sealed chemical protective clothing and the full-face mask, were found here and there. Not only was it necessary to explain safety to workers scientifically, but also it was also important to remove workers' anxiety.
- For the workers, not only radiation protection but also measures to protect from pests (particularly bees and vipers) were necessary. In addition, it was found that measures to protect workers from the danger caused by livestock and pets which had gotten free from owners were necessary.
- It was not only residents that felt uneasy as to whether decontamination was carried out appropriately. It was found that there was a case in which workers were performing decontamination works while feeling uneasy whether the works were being carried out appropriately. Particularly, in the topsoil stripping by human power, it was difficult to check whether there was any omission of stripping or any unremoved soil by only visual inspection. Therefore, personnel qualified to make dose measurements were present in the fields during decontamination works, and the effect of dose reduction was confirmed in a timely manner. This was effective in the prevention of redoing of decontamination works and in the prevention of excessive decontamination.

1.1.7. Outline of the Intensive Contamination Survey Areas

(1) Designation of Intensive Contamination Survey Areas

Intensive Contamination Survey Areas are designated by the MOE as the areas where it is necessary to investigate and measure the status of the environmental contamination due to the radioactive materials discharged in the areas by the accident mainly.

In Intensive Contamination Survey Areas, designated municipal mayors have developed their decontamination plans unlike those of the Special Decontamination Areas as described in 1.1.4, and municipalities have been implementing decontamination works steadily.

(2) Designation status of Intensive Contamination Survey Areas

The designation status of Intensive Contamination Survey Areas is not fixed because there are also some areas where the designation was lifted after the determination[65]. The municipalities listed in Table 1-7 are the designated the Intensive Contamination Survey Area as of February 1, 2015. Municipalities designated

[65] For some municipalities, the designation of Intensive Contamination Survey Area was lifted because the decrease in air dose rates led to the fact of the qualification for designation.

as the Intensive Contamination Survey Area and Special Decontamination Area are shown in Figure 1-22 through Figure 1-29, together with the progress of decontamination works in those municipalities.

Table 1-7 Designation status of Intensive Contamination Survey Areas (as of February 1, 2015)[66]

Prefectures	Municipalities
Fukushima Prefecture	Fukushima City, Koriyama City, Iwaki City, Shirakawa City, Sukagawa City, Soma City, Nihonmatsu City, Date City, Motomiya City, Koori Town, Kunimi Town, Otama Village, Kagamiishi Town , Tenei Village, Aizubange Town, Yugawa Village, Yanaizu Town, Aizu Misato Town, Nishigo Village , Izumizaki Village, Nakajima Village, Yabuki Town, Tanagura Town, Yamatsuri Town, Hanawa Town, Samegawa Village, Ishikawa Town, Tamagawa Village, Hirata Village, Asakawa Town, Furudono Town, Miharu Town, Ono Town, Hirono Town, Shinchi Town, Tamura City, Minami Soma City, Kawamata Town And Kawauchi Village
Iwate Prefecture	Ichinoseki City, Oshu City, Hiraizumi Town
Miyagi Prefecture	Shiroishi City, Kakuda City, Kurihara City, Shichikashuku Town, Ogawara Town, Marumori Town, Watari Town, Yamamoto Town
Ibaraki Prefecture	Hitachi City, Tsuchiura City, Ryugasaki City, Joso City, Hitachiota City, Takahagi City, Kitaibaraki City, Toride City, Ushiku City, Tsukuba City, Hitachinaka City, Kashima City, Moriya City, Inashiki City, Hokota City, Tsukubamirai City, Tokai Village, Miho Village, Ami Town, Tone Town
Tochigi Prefecture	Sano City, Kanuma City, Nikko City, Otawara City, Yaita City, Nasushiobara City, Shioya Town, Nasu Town
Gunma Prefecture	Kiryu City, Numata City, Shibukawa City, Annaka City, Midori City, Shimonita Town, Nakanojo Town, Takayama Village, Higashiagatsuma Town, Kawaba Village
Saitama Prefecture	Misato City, Yoshikawa City
Chiba Prefecture	Matsudo City, Noda City, Sakura City, Kashiwa City, Nagareyama City, Abiko City, Kamagaya City, Inzai City, Shiroi City

[66]Source: Ministry of the Environment (MOE), "Decontamination information site"
(the same source for Figure 1-22 to Figure 1-29)

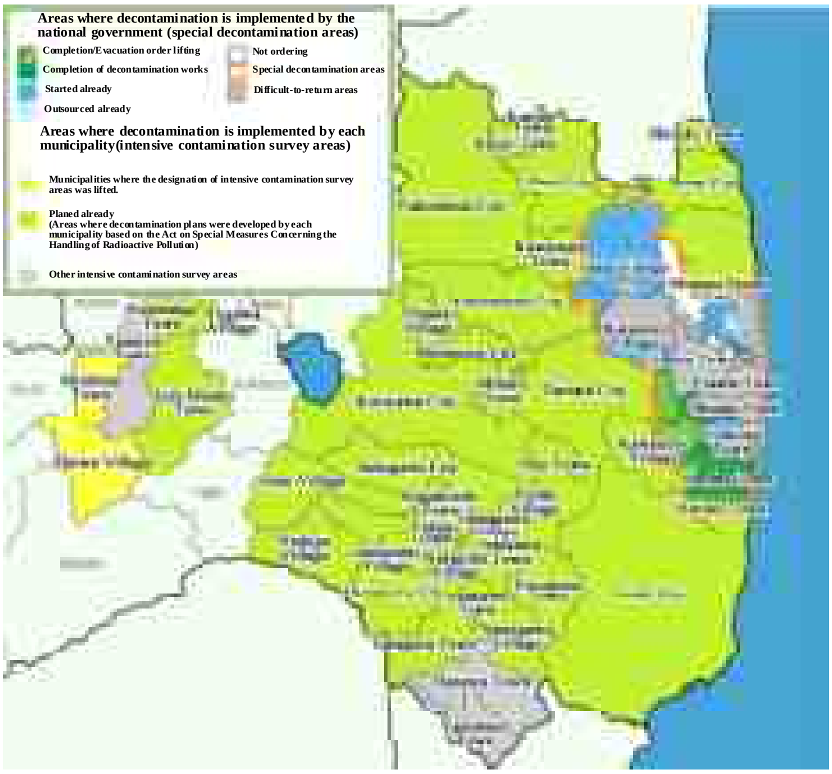


Figure 1-22 Designation status of Intensive Contamination Survey Area/ Special Decontamination Area and progress of decontamination works in Fukushima Prefecture.

Figure 1-23 Designation status of Intensive Contamination Survey Area and progress of decontamination works in Iwate Prefecture.

Figure 1-24 Designation status of Intensive Contamination Survey Area and progress of decontamination works in Miyagi Prefecture.

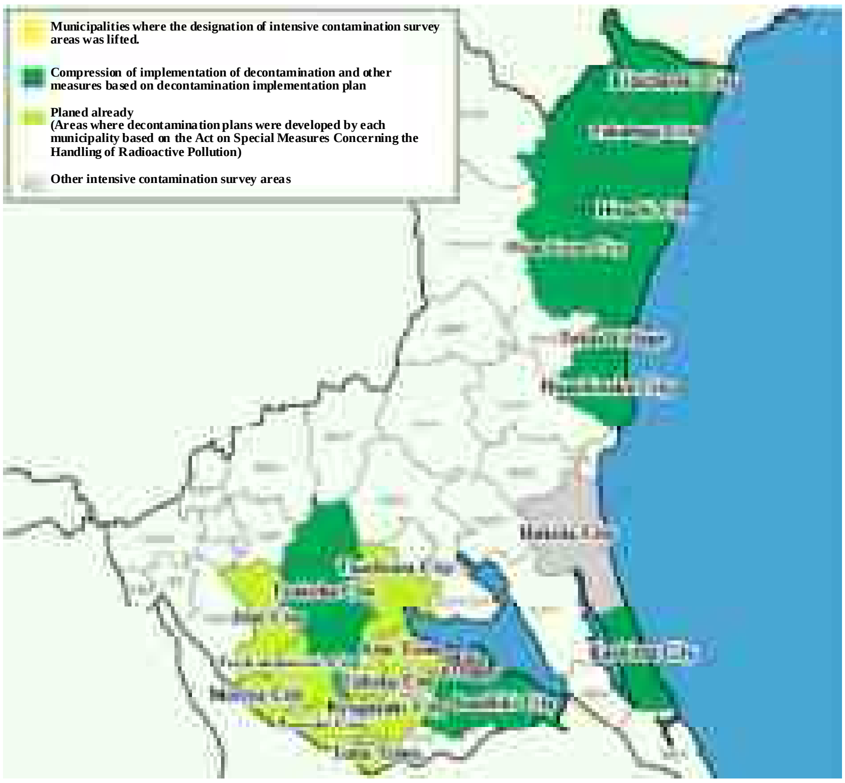


Figure 1-25 Designation status of Intensive Contamination Survey Area and progress of decontamination works in Ibaraki Prefecture.

Figure 1-26 Designation status of Intensive Contamination Survey Area and progress of decontamination works in Tochigi Prefecture.

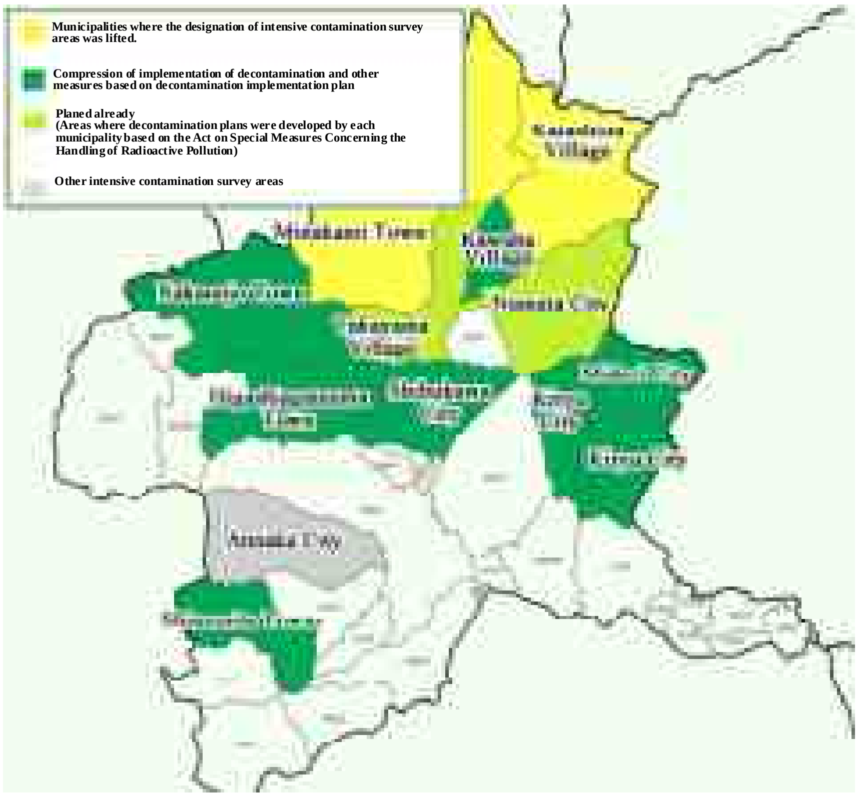


Figure 1-27 Designation status of Intensive Contamination Survey Area and progress of decontamination works in Gunma Prefecture.

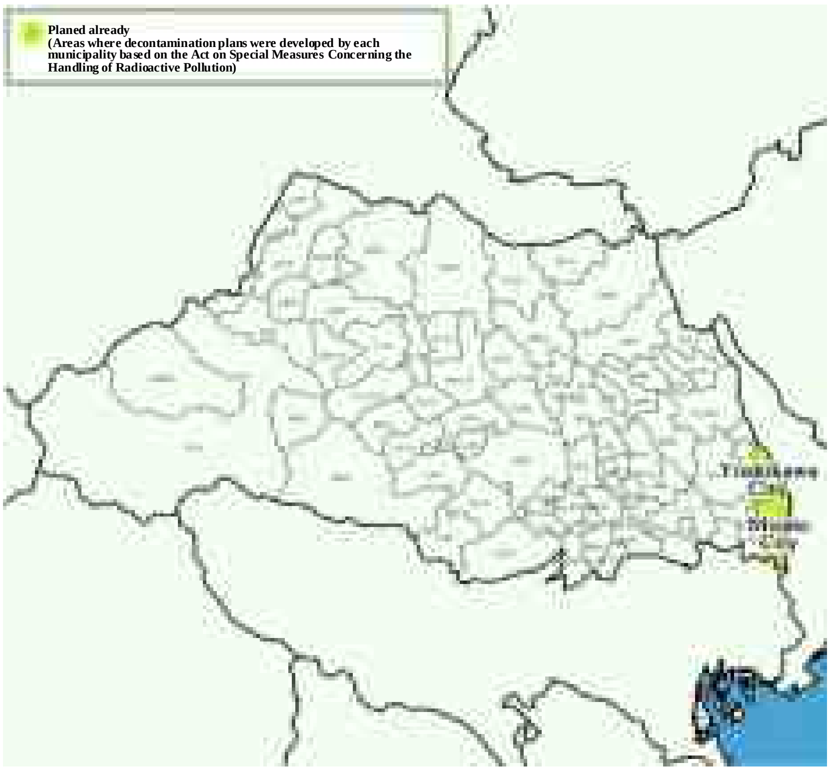


Figure 1-28 Designation status of Intensive Contamination Survey Area and progress of decontamination works in Saitama Prefecture.

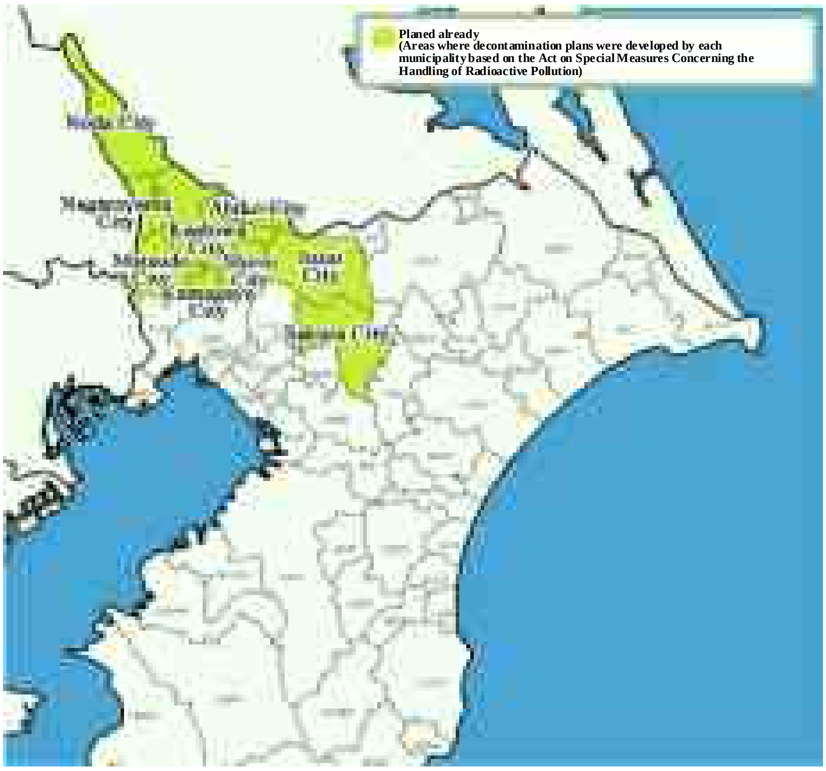


Figure 1-29 Designation status of Intensive Contamination Survey Area and progress of decontamination works in Chiba Prefecture.

（3） Implementation system of decontamination works in Intensive Contamination Survey AreasIn Intensive Contamination Survey Areas, surveys and measurements of the contamination status are carried out first by the mayors and other officials of the municipalities with financial support by the National Government.

Based on the results of surveys and measurements, decontamination plans are developed by the mayors and others. In formulating the decontamination plan in each municipality, the consultation with the Minister of the Environment is done in advance. Through this consultation, determinations and recommendations are made about the adequacy of plan contents, and then planning is checked whether it corresponds to the works targeted for the budget support.

After the check has been completed, securing of temporary storage sites, reaching the consensus with stakeholders about the decontamination works, ordering of the decontamination works, implementing the decontamination works, and post-work investigation and verification are carried out sequentially by each municipality, in accordance with their own decontamination plan. All the costs for these works by each municipality are covered with the National Government financial support.

In addition, for the implementation of decontamination works in the target areas described in each municipality's plan, it is prescribed in the Act on Special Measures that the National Government has the responsibility for the land under national control, and each prefecture has the responsibility for the land under its own control.

（4） Progress in Intensive Contamination Survey Areas

Progress of implementation of the decontamination works and other measures in Intensive Contamination Survey Areas are described below for Fukushima Prefecture and other prefectures.

1）Fukushima Prefecture

Status of the ordering of decontamination works and the development of decontamination plans in Fukushima Prefecture is shown in Figure 1-30. Most ordering has been completed. However, for roads and forests (in the living space), the progress of their ordering is delayed.

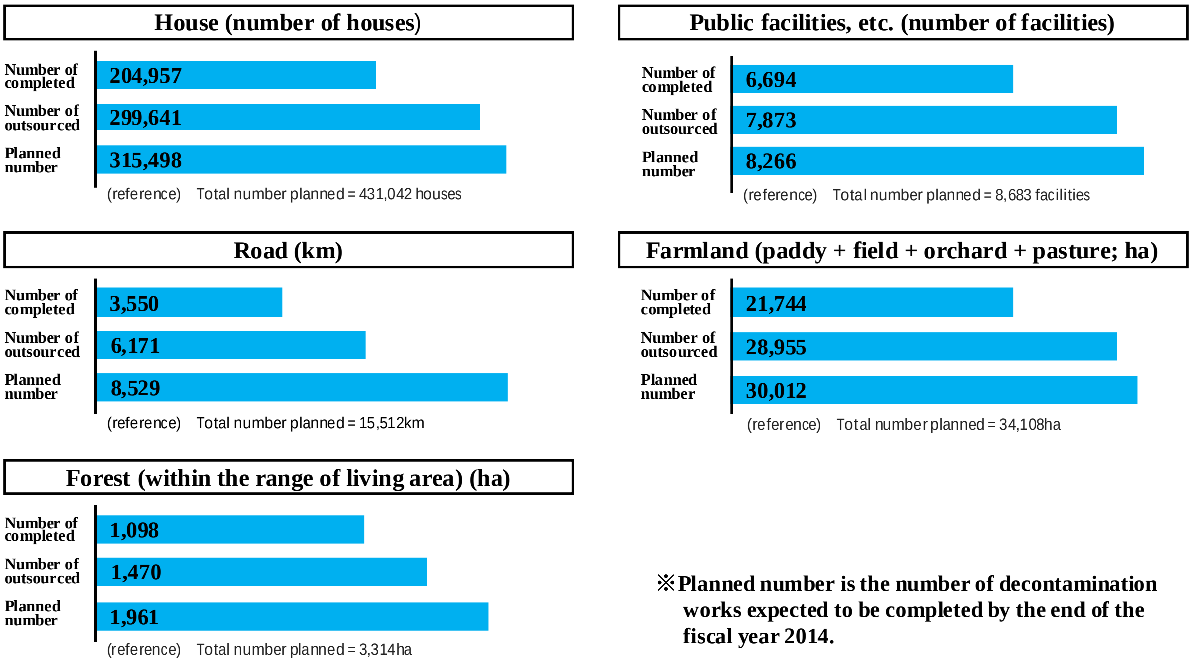


Figure 1-30 Progress of decontamination works in Intensive Contamination Survey Areas in Fukushima Prefecture (as of end of January 2015)[67].

2）Outside Fukushima Prefecture

Implementation status of decontamination and other measures in Iwate, Miyagi, Ibaraki, Tochigi, Gunma, Saitama and Chiba Prefectures is shown in Table 1-8 through Table 1-15.

The decontamination has already been completed or almost been completed in more than 70% of the municipalities.

Table 1-8 Completion status of implementation of decontamination and other measures based on decontamination implementation plans outside Fukushima Prefecture[68]

(as of end of December, 2014) (Number of municipalities)

	(a)Completed	(b)Almost completed	(c)Continued	(d)Total
Iwate Prefecture	0	2	1	3
Miyagi Prefecture	0	3	5	8
Ibaraki Prefecture	11	7	1	19
Tochigi Prefecture	0	4	4	8
Gunma Prefecture	7	1	1	9
Saitama Prefecture	0	2	0	2
Chiba Prefecture	0	8	1	9
Total number	17	26	15	58

[67]Source: Fukushima Prefecture, "Decontamination implementation status in decontamination areas (Intensive Contamination Survey Areas) in municipalities (February 27, 2015 update) " （https://www.pref.fukushima.lg.jp/site/portal/progress201501.html

[68]Source: Ministry of the Environment (MOE), "Compiled of progress survey results (as of end of December, 2014)" (February 13, 2015) (the same source for Table 1-9 to Table 1-15)

Table 1-9 Progress of implementation of decontamination and other measures based on decontamination implementation plan outside Fukushima Prefecture (Schools and nursery schools, etc.)

(as of end of December, 2014) (Number of facilities)

	(a)Planned number	(b)Outsourced number	(c)Completed number	Number of unnecessary decontamination works in (a),(b) and (c) [the number that decontamination works were determined to be unnecessary by prior monitoring results]
Iwate Prefecture	242	242	242	(54)
Miyagi Prefecture	95	95	94	(10)
Ibaraki Prefecture	329	329	329	(42)
Tochigi Prefecture	232	232	231	(5)
Gunma Prefecture	24	24	24	(7)
Saitama Prefecture	48	48	48	0
Chiba Prefecture	593	593	593	(99)
Total number	1,563	1,563	1,562	(217)

Table 1-10 Progress of implementation of decontamination and other measures based on decontamination implementation plan outside Fukushima Prefecture (Parks and sports facilities)

(as of end of December, 2014) (Number of facilities)

	(a)Planned number	(b)Outsourced number	(c)Completed number	Number of unnecessary decontamination works in (a),(b) and (c) [the number that decontamination works were determined to be unnecessary by prior monitoring results]
Iwate Prefecture	335	335	335	(268)
Miyagi Prefecture	153	150	149	(56)
Ibaraki Prefecture	888	887	887	(335)
Tochigi Prefecture	741	736	436	(241)
Gunma Prefecture	41	41	41	(18)
Saitama Prefecture	94	94	94	0
Chiba Prefecture	1,672	1,672	1,672	(143)
Total number	3,924	3,915	3,614	(1,061)

Table 1-11 Progress of implementation of decontamination and other measures based on decontamination implementation plan outside Fukushima Prefecture (Housing)

(as of end of December, 2014)　(Number of houses/buildings)

	(a)Planned number	(b)Outsourced number	(c)Completed number	Number of unnecessary decontamination works in (a),(b) and (c) [the number that decontamination works were determined to be unnecessary by prior monitoring results]
Iwate Prefecture	18,621	15,321	15,321	(15,207)
Miyagi Prefecture	10,228	8,503	7,350	(2,972)
Ibaraki Prefecture	47,276	47,276	47,266	(45,143)
Tochigi Prefecture	38,054	37,718	34,065	(13,712)
Gunma Prefecture	6,192	6,192	6,165	(4,760)
Saitama Prefecture	0	0	0	0
Chiba Prefecture	19,159	19,159	19,159	(10,919)
Total number	139,530	134,169	129,326	(92,713)

Table 1-12 Progress of implementation of decontamination and other measures based on decontamination implementation plan outside Fukushima Prefecture (Other facilities)

(as of end of December, 2014)　(Number of facilities)

	(a)Planned number	(b)Outsourced number	(c)Completed number	Number of unnecessary decontamination works in (a),(b) and (c) [the number that decontamination works were determined to be unnecessary by prior monitoring results]
Iwate Prefecture	3,098	2,577	2,577	(2,445)
Miyagi Prefecture	348	348	332	(180)
Ibaraki Prefecture	634	634	634	(543)
Tochigi Prefecture	402	353	223	(136)
Gunma Prefecture	123	122	122	(86)
Saitama Prefecture	8	8	8	0
Chiba Prefecture	227	227	227	(130)
Total number	4,840	4,270	4,124	(3,520)

Table 1-13 Progress of implementation of decontamination and other measures based on decontamination implementation plan outside Fukushima Prefecture (Roads)

(as of end of December, 2014) (m)

	(a)Planned number	(b)Outsourced number	(c)Completed number	Number of unnecessary decontamination works in (a),(b) and (c) [the number that decontamination works were determined to be unnecessary by prior monitoring results]
Iwate Prefecture	2,151,600	2,140,600	2,140,600	(2,140,400)
Miyagi Prefecture	332,409	73,232	73,232	(32,726)
Ibaraki Prefecture	1,164,205	1,120,705	1,120,705	(1,117,240)
Tochigi Prefecture	81,402	81,402	81,402	(76,875)
Gunma Prefecture	203,378	203,378	203,378	(201,502)
Saitama Prefecture	3,409	3,409	3,409	0
Chiba Prefecture	232,874	232,874	232,874	(137,388)
Total number	4,169,277	3,855,600	3,855,600	(3,706,131)

Table 1-14 Progress of implementation of decontamination and other measures based on decontamination implementation plan outside Fukushima Prefecture (Farmland and pastures)

(as of end of December, 2014) (m^2)

	(a)Planned number	(b)Outsourced number	(c)Completed number	Number of unnecessary decontamination works in (a),(b) and (c) [the number that decontamination works were determined to be unnecessary by prior monitoring results]
Iwate Prefecture	0	0	0	0
Miyagi Prefecture	557,000	557,000	217,000	0
Ibaraki Prefecture	0	0	0	0
Tochigi Prefecture	12,278,300	12,278,300	12,142,000	(3,755,900)
Gunma Prefecture	1,043,597	1,043,597	1,043,597	(951,708)
Saitama Prefecture	0	0	0	0
Chiba Prefecture	0	0	0	0
Total number	13,878,997	13,878,897	13,402,597	(4,707,608)

Table 1-15 Progress of implementation of decontamination and other measures based on decontamination implementation plan outside Fukushima Prefecture (Forests (Nearby living areas))

(as of end of December, 2014) (m^2)

	(a)Planned number	(b)Outsourced number	(c)Completed number	Number of unnecessary decontamination works in (a),(b) and (c) [the number that decontamination works were determined to be unnecessary by prior monitoring results]
Iwate Prefecture	0	0	0	0
Miyagi Prefecture	2,000,000	2,000,000	1,029,709	(185,355)
Ibaraki Prefecture	7,186	7,186	7,186	0
Tochigi Prefecture	831,760	831,760	831,760	0
Gunma Prefecture	60,155	54,555	53,755	(38,563)
Saitama Prefecture	0	0	0	0
Chiba Prefecture	0	0	0	0
Total number	2,899,101	2,893,501	1,922,410	(223,918)

1.2. Features of contamination

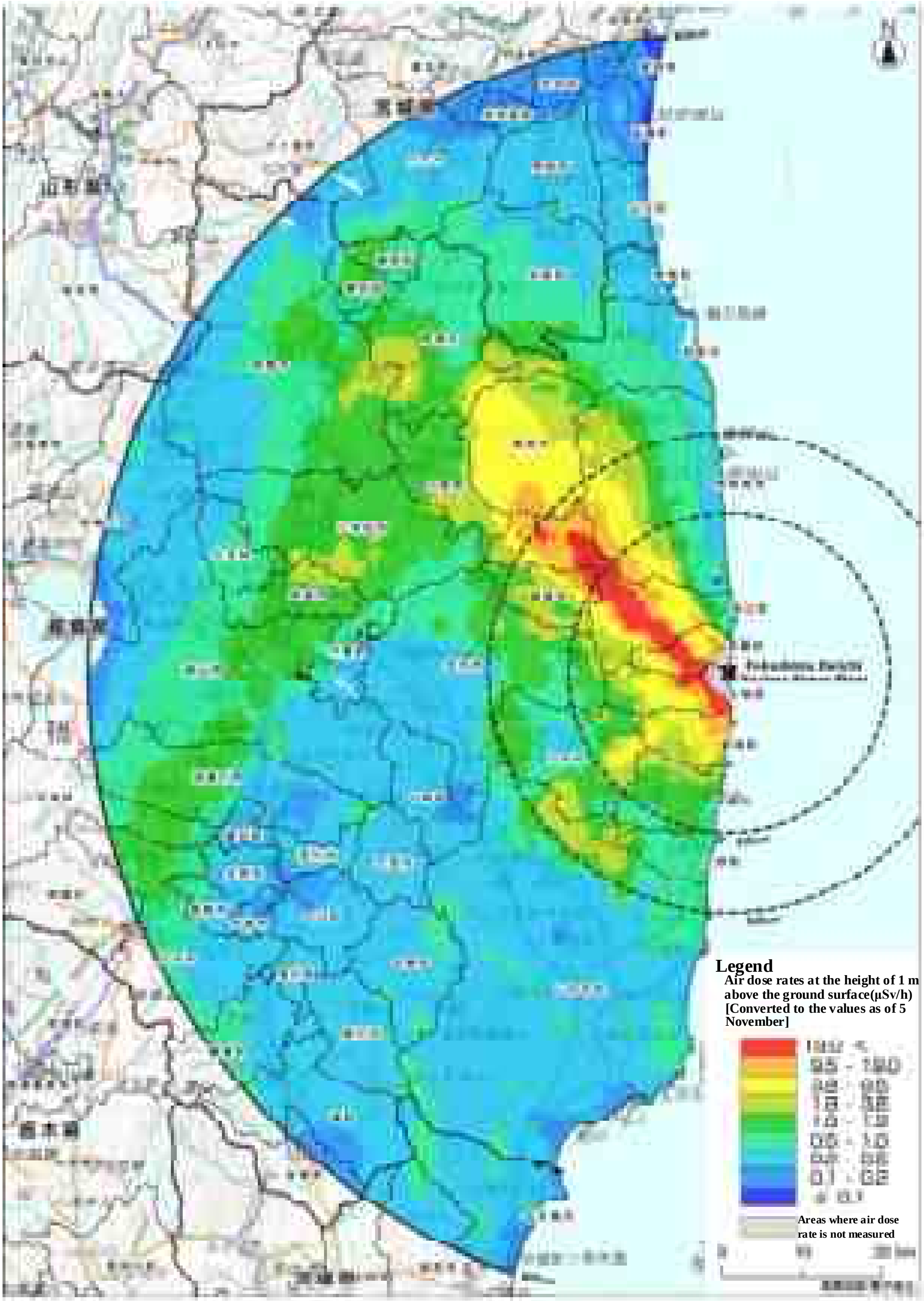
1.2.1. Dispersion status of radioactive materials

Radioactive materials were discharged from the damaged nuclear reactors at the 1FNPS. The total amount of radioactive materials discharged in the period between March 11 and April 5, 2011, was estimated to be approximately 1.5 x 10^{17} Bq for iodine-131 and approximately 1.3 x 10^{16} Bq for cesium-137 (estimated based on the data of environmental monitoring, etc. using an atmospheric dispersion factor)[69]. A massive amount of radioactive materials was dispersed into the atmosphere.

The results of various monitoring surveys confirmed that radioactive materials had dispersed into wide areas, not only into the evacuated areas but also into areas outside those defined as evacuation areas, as a result of the accident, as mentioned in 1.1.2. For reference, Figure 1-31 shows the result of a monitoring survey which was done using an aircraft by the MEXT during the period between October 22 and November 5, 2011. As understood when compared with the evacuation area shown in Figure 1-13, contamination was confirmed not only in the areas to which an evacuation order was made (and residents were no longer present), but also in the areas with residents present. The dose reduction activities were needed in such areas.

Because radioactive materials move over time as they are carried by rainfall and other factors and the ease of accumulation varies by place, depending on the shape and material of structural objects, the dose distribution had become uneven over time compared to the condition immediately after the accident, and there occurred some localized high-dose points called hot spots (Figure 1-33). Such unevenly contaminated conditions in micro and macro terms led to a difference in decontamination methods by areas and buildings and accordingly caused concerns of the residents about the existence of high radiation sources in nearby areas, as well as affecting their sense of fairness for the level of decontamination by area and house. Detailed explanations and appropriate responses were required to address these issues.

[69] Source: JAEA, "Summary of Estimation of Release Amounts of ^{131}I and ^{137}Cs Accidentally Discharged from Fukushima Daiichi Nuclear Power Plant into the Atmosphere” (May 12, 2011)



* Air dose rate due to natural radionuclides is included in this map.

Figure 1-31 Result of the Fourth Airborne Monitoring Survey (October to November 2011) by MEXT (Air dose rates at the height of 1 m above the ground surface within an 80 km zone from the 1FNPS)[70].

[70]Source: Ministry of Education, Culture, Sports, Science and Technology (MEXT), "Result of the Fourth Airborne Monitoring Survey by MEXT" (December 16, 2011) (the same source for Figure 1-32)

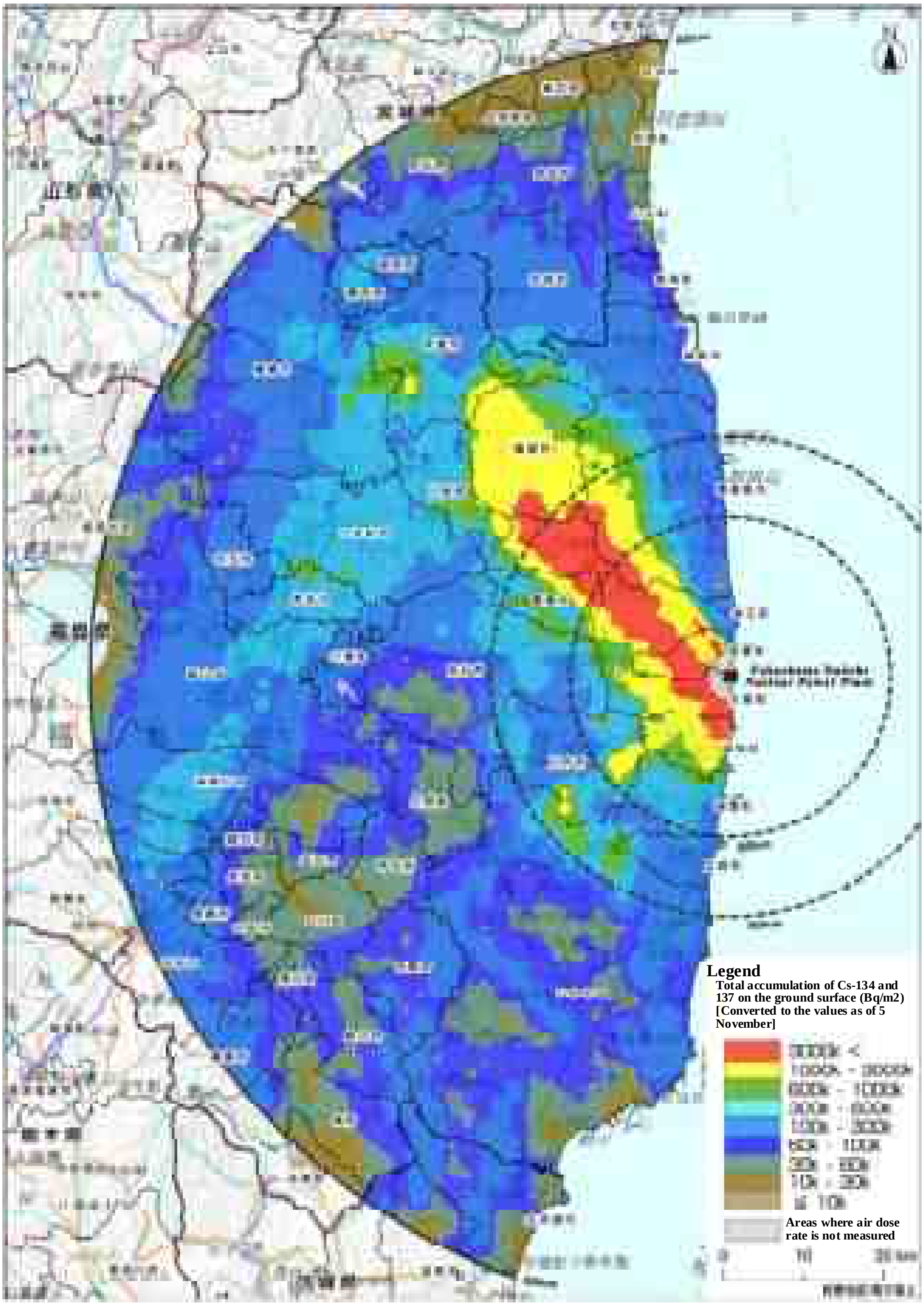
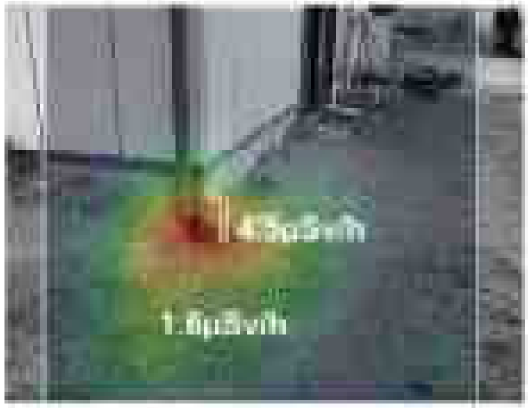


Figure 1-32 Result of the Fourth Airborne Monitoring Survey (October to November 2011) by MEXT (Total accumulation of ^{134}Cs and ^{137}Cs on the ground surface within an 80 km zone from the 1FNPS).

Aizubange Town

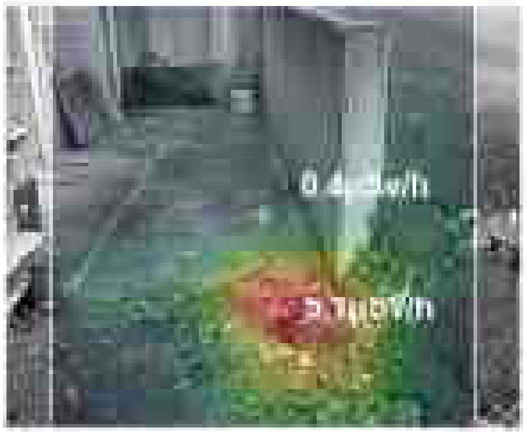
Place where rainwater flows and drops



Bottom of downspout

Onami district, Fukushima-City

Exit of downspout



Place where rainwater flows

Figure 1-33 Monitoring of contamination status with gamma camera images at the hotspot locations[71].

1.2.2. Major nuclides

Released radioactive materials included xenon-133, tellurium-132, strontium and plutonium in addition to cesium and iodine.

Among them, strontium and plutonium were monitored from June 6 through June 14 and from June 27 through July 8, 2011 by the MEXT). As a result, plutonium-238 and plutonium-(239+240) were detected in the northwest direction within the radius of 45 km from TEPCO's 1FNPS, as shown in Figure 1-34. However, the amount was within the monitoring level of the deposition quantity of plutonium due to atmospheric nuclear tests which had been monitored nationwide for 11 years before the accident, except for one place (1.4 times of the maximum amount of plutonium monitored before the accident). Relatively high amount of strontium-89 and -90 has also been monitored on the ground surface in the northwest direction from the 1FNPS. However, those quantities indicated a tendency to decrease as the distance got away from the power station. Based on these measurements, cumulative effective doses of 50 years were calculated for every radionuclide which was deposited on the soil. As a result of these analyses, it was confirmed that the

[71]Source: "Discussion meeting with well-informed persons about decontamination ~ Considering future from the former knowledge in National Government and 4 cities ~ Fact book" (June 20, 2014 edition)(http://josen.env.go.jp/material/pdf/session_140615/session_140615_03_140620.pdf)

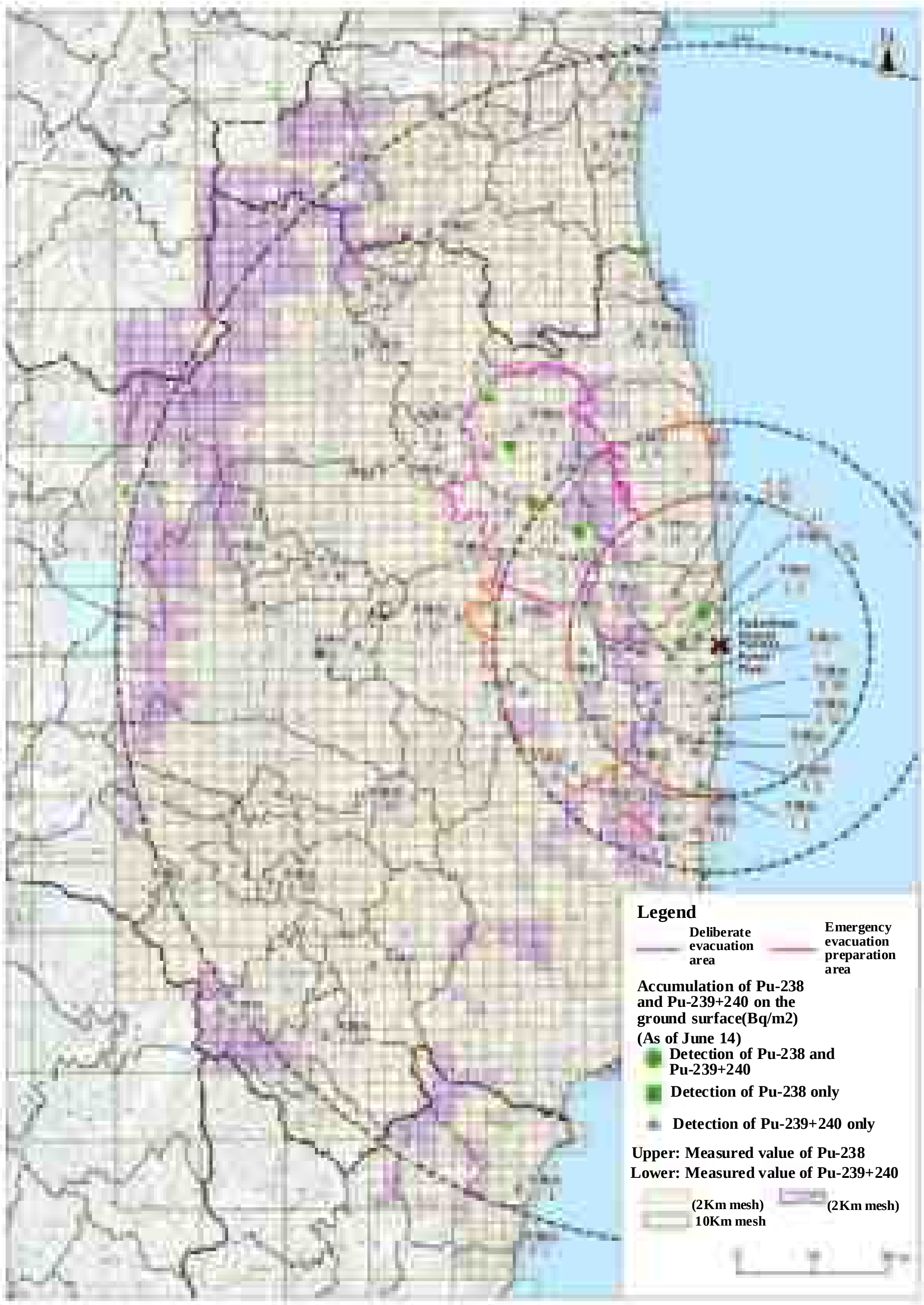
influences of radiation exposure due to the nuclides other than radioactive cesium are very small compared with those of radioactive cesium that was released in large quantities[72].

Furthermore, as the half-lives of iodine 131, Xenon 133 and tellurium 132 are short with approximately eight days, five days and three days, respectively, the influence of radioactive exposure due to these nuclides becomes small after the early days of the accident. Therefore when considering person's radiation exposure at present, important nuclides have become two of cesium 134 (half-life; about 2.1 years) and cesium 137 (half-life; about 30.2 years).

[72]According to the "Results of nuclide analyses of plutonium and strontium by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)", those are as follows. Cumulative effective doses of 50 years have been analyzed in each place where the highest values were detected in the deposition amounts of plutonium-238, plutonium-(239+240), and strontium-89 and -90. For them, plutonium-238 was 0.027 mSv, plutonium-(239+240) was 0.12 mSv. Strontium-89 was 0.61μSv (0.00061 mSv), and strontium-90 was 0.12 mSv.

On the other hand, those values of cesium-134 and -137 were 71mSv and 2.0Sv (2,000mSv), respectively, in each place where the highest values were detected for the deposition amounts of cesium-134 and -137.

In addition, in these analyses, the effect of dose reduction by decontamination is not included, and it is assumed to have stayed the same at the same place for 50 years.



Places where plutonium 238 and 239+240 are considered to have been deposited newly due to the accident of Fukushima Daiichi nuclear power plant

Figure 1-34 Measurement results of ^{238}Pu and $^{239+240}$Pu on the ground surface[73].

[73]Source: Ministry of Education, Culture, Sports, Science and Technology (MEXT), "Results of nuclide analyses of plutonium and strontium by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)" (September 30, 2011) (the same source for Figure 1-36)

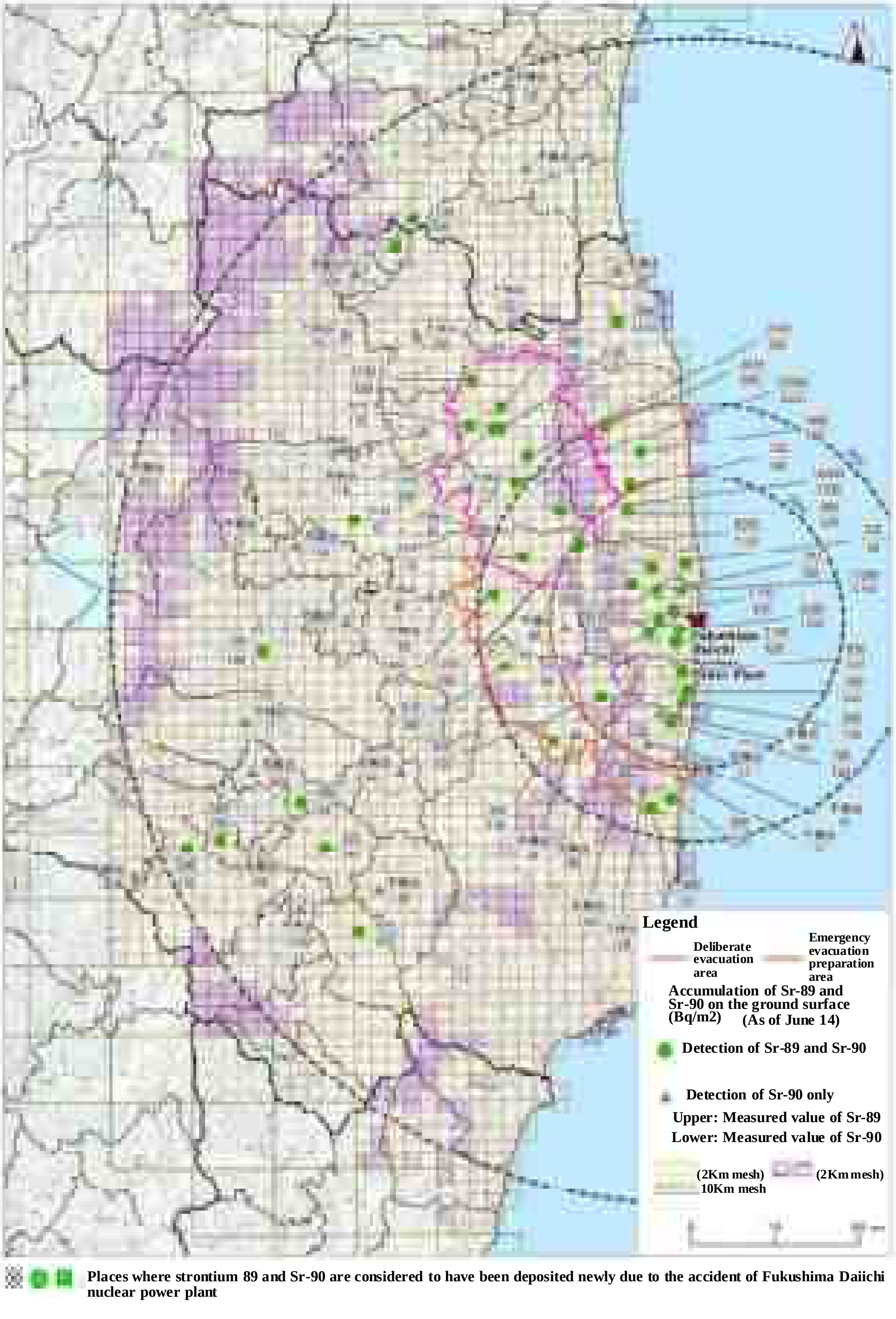


Figure 1-35 Measurement results of ^{89}Sr and ^{90}Sr on the ground surface.

1.3. Features of decontamination

1.3.1. Unprecedented large-scale decontamination activities

Since radioactive materials have been dispersed across a wide area, decontamination works in Japan associated with the accident at the 1FNPS have to be done in vast areas as indicated in 1.1.2 and 1.1.3: it is an extremely large-scale project that has not been seen before. We are also required to promote large-scale decontamination projects that no one has ever done before, while obtaining the consents of related persons, such as owners of residential land. Moreover, we faced a large number of problems, as we did not have enough time for planning. To solve these problems, various measures were taken and considerable efforts were made.

（1） Establishment of strategic decontamination process

1）Implementation of large-scale decontamination with strategic decontamination process

The areas subjected to decontamination are extremely broad. There are several tens of thousands to hundreds of thousands of residential land lots from which it is necessary to obtain consent, which means the number of involved persons such as owners is enormous and a great amount of time and manpower is required to obtain their consent. Therefore, it is not necessarily efficient to hastily start a large amount of decontamination works at one time before putting in place the system for decontamination.

To address such a situation, we implemented the “Demonstration model project for decontamination” especially in the Special Decontamination Areas where the residents had been evacuated and no restored infrastructures had been put in place. Through decontaminating local government offices and public facilities first, while confirming and accumulating achievements and technical knowledge, we formed bases for decontamination and restoration/reconstruction works, which led to smooth large-scale decontamination (full-scale decontamination) works later.

In the full-scale decontamination, the strategic efforts by building bases were seen as with the case of preliminary decontamination: these efforts were intended to increase the speed of decontamination works as much as possible and improve the workplace safety of the workers by first decontaminating the workers’ base for taking a rest.

2）Decontamination plan based on the weather

The weather varies greatly from season to season in Japan.

The demonstration model project for decontamination has proved that especially in winter it is difficult to get accurate values of air dose rate due to the shielding effect of falling and accumulated snow and there is a reduction in decontamination efficiency, increase in weight and volume of waste due to the attachment of snow and problems in using cars, etc., as indicated in 1.1.6 (7). Therefore, it has become a general rule not to perform decontamination forcedly during the time of snowfall and accumulation in the full-scale decontamination.

Also, in the rainy and typhoon seasons, there are many concerns, including those for measuring error, outflow of materials removed by decontamination, problems in recovering decontamination waste water and concerns about worsening of the labor environment for decontamination workers. Therefore, we make it a rule to stop the decontamination works under certain conditions of wind and rain.

Because we sometimes need to postpone the schedule of decontamination due to weather conditions, we need to plan work schedules taking into account these impacts.

Although high temperature and solar insulation in summer do not affect the decontamination work itself, they may result in a harsh working environment and have impacts on the health of decontamination workers. To address such a situation, we decided to work on decontamination with due considerations for prevention of heat stroke and response to sudden illness depending on the weather, including wearing of protective clothing with cold packs and avoidance of working during hours when temperatures are the highest, as well as raising the awareness of workers about heat stroke.

(2) Securing decontamination workers

1) Securing the quantity of decontamination workers

While the decontamination work does not necessarily require a high level of skill, it has to be done with consideration for the level of radiation dose and conditions of the decontamination objectives. Also, only a very limited part can be done by machine. As a result, we need a large number of workers: the numbers of local workers that can be employed are not sufficient to secure the required number of decontamination workers, and we needed to recruit widely from outside Fukushima Prefecture.

However, the Great East Japan Earthquake which sled to the accident at the nuclear power station, inflicted massive damage on the Tohoku region, mainly to Miyagi, Iwate and Fukushima Prefectures as mentioned in 1.1.2 There have been large-scale restoration/reconstruction projects after the earthquake underway in Miyagi and Iwate Prefectures, and there has been a great demand for construction workers doing decontamination and other works also in the prefectures other than Fukushima. Therefore, it has been very difficult to secure the required number of decontamination workers.

Furthermore, many workers were required for works to be done on the site of the 1FNPS, which added to the difficulty to secure the necessary number of decontamination workers.

Therefore, the MOE and local governments have worked to reduce concerns for becoming a decontamination worker, by introducing the details of decontamination work in an easy-to-understand way. In addition, they tried to secure decontamination workers by implementing various measures, including payment of a special allowance in the Special Decontamination Areas.

2) Securing the quality of decontamination workers

Although decontamination work does not necessarily require a high level of skill, sufficient effects may not be obtained if workers do not know the principle of decontamination and do not follow a certain procedure. Moreover, since radiation is not visible unlike ordinary contamination and dust, it has the feature that we cannot tell whether a sufficient decontamination effect is obtained or not without measurement. If appropriate decontamination work is not done, it could lead to not only an increase of removed substances, but also problems with residents. Therefore, securing the quality, as well as the quantity, was required in recruiting decontamination workers.

On the other hand, it was difficult to secure a large number of workers who had knowledge and experience in decontamination and radiation from the outset, because general citizens were not familiar with the knowledge of radiation, let alone decontamination, in Japan before the Great East Japan Earthquake as mentioned in 1.1.1 Therefore, we had no choice but to nurture the knowledge of decontamination through education. The efforts were made to provide many workers with education about decontamination. For example, decontamination business operators provided the special education and the newcomer education based on the Ionizing Radiation Ordinance for decontamination to workers before starting decontamination work, as well as regular education and training on safety. They also implemented accident prevention activities and mutual checking of radiation protection measures among workers on the site of work every morning before starting decontamination work. In addition to the above, they themselves extracted and presented example cases of successes and failures at work sites. The MHLW transmitted animated materials for special education about decontamination on YouTube and Fukushima Prefecture and MOE held training sessions on decontamination work for decontamination workers and site supervisors. These efforts helped decontamination business operators perform educational activities more smoothly and easily.

Furthermore, decontamination workers are required to be of sufficient quality in terms of consideration to related persons and local residents as shown in 1.3.3, as well as in terms of knowledge about decontamination. Especially, those from outside the decontamination area were required to exhibit behavior and awareness worthy of getting the trust of related persons and residents.

Moreover, the work of decontamination is unlikely to give a sense of accomplishment to workers, unlike civil engineering work and construction which are actions of making structural objects. A high level of patience is also required for decontamination workers to continue the work without degrading its quality, because they have to continue relatively monotonous work of decontamination endlessly while placing extra effort on radiation protection. Therefore, how to maintain the motivation of the workers was a critical issue.

The workers from the disaster-affected areas could maintain their motivation when they saw the improved appearance as a result of their work such as mowing and they could feel their hometowns were being restored. However, it is not always true for the workers from outside the areas. To maintain and secure their motivation, various efforts were made, including making repetitive communications about what their efforts would bring about, showing the effects of their work by comparing the data before and after decontamination, and conveying voices of appreciation and encouragement from the local people.

（3） Preparation of project environment

To perform this great amount of unprecedented decontamination work, it is also important to prepare uniform procedures and systems to order and perform the work smoothly as a project, as well as the strategic process as shown in (1) above and the securing of the quantity and quality of workers as shown in (2) above.

Since there were a limited number of personnel at the MOE who had the experience of implementing public works as a direct control project, they used the existing rules and systems that had been established by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the MAFF, while obtaining help from personnel of the two ministries who had many experiences of doing such works. Thus, the MOE temporarily created the common specifications and other rules (hereinafter referred to as the “Common Specifications”) that were required to implement the decontamination and other construction works as a direct control project by searching for a way and starting the decontamination work. After that, they continued to improve the specifications step-by-step according to the actual conditions of the decontamination sites through a trial and error process. As a result of these efforts, they established the rules from the framework of the entire decontamination work to specific construction work implementation methods to a certain extent to enable a quick start of the decontamination works. They also strove to ensure the quality of works.

On the other hand, while we can create design documents for conventional civil engineering work in advance, we have to place an order based on approximate figures for decontamination, because orders are placed before consent forms are collected. Therefore, we needed to agree on a construction unit price in advance so that we could adjust an account after implementing decontamination work.

Also, although we need to provide documents about unit price for each decontamination objective at the time of placing an order, it was difficult to accurately determine the unit prices[74] in advance. Therefore, we estimated the unit prices to allow quick order placement by setting up a team, which included staff members from the MLIT and the MAFF who had many experiences in placing orders for civil engineering work, based on the results of decontamination that had been implemented independently under the model project of the Cabinet Office, as well as by Fukushima Prefecture and municipalities. The situation assumed under the model project may not always apply to the actual sites of decontamination, because there are different conditions such as the existence of newly growing trees after the earthquake. Therefore, we promoted a PDCA (Plan-Do-Check-Act) cycle energetically, through changing actual work depending on the condition of the site and providing feedback about the results. There were also some cases in which we had to do work on the site that had not been specified in the decontamination guidelines or the Common Specifications. In such cases, the work was done through trial and error and discussions between the supervising officials from the National Government and the decontamination business operators. Such knowledge was shared among the supervising officials to be reflected in the Common Specifications and other documents when appropriate.

If we try to respond easily to the request of related persons, it may cause a risk of excessive decontamination. The excessive decontamination would increase the total amount of removed

[74] Unit price represents a quantified amount of time and effort that is required for a certain task.

materials, as well as cause a feeling of unfairness among other related persons. To prevent these problems, we standardized the judgment on reasonableness for the entire project, and included it as a new rule in the standard procedures, if it could be theorized or generalized to ensure consistency.

In addition, the National Government improved the environment for decontamination work on the site, as well as created a good project environment by preparing documents. For example, there is a concern that the amount of daily life waste disposal and sewage treatment might exceed the existing disposal/treatment capacity, as a result of a significant number of workers being expected to come from other local communities and prefectures. We worked to avoid such a shortage of treatment capacity by ensuring exchange and confirmation of information between the National Government and local governments in advance, without fully leaving the response to decontamination business operators.

1.3.2. Decontamination to secure safety at an early stage and to facilitate restoration and reconstruction

（1） Acceleration of project through sharing information and promoting PDCA cycle

Since early stage securing of safety and restoration/reconstruction was required, we had to start the decontamination project without sufficient lead-time for conducting sufficient policy preparation. Therefore, we focused on the PDCA cycle and incorporated information that had not been prepared or known in the preparation stage moment to moment to compensate for the lack of time at the preparation stage. A part of such efforts is mentioned in Section 1.3.1.(3).

In large-scale decontamination works that are performed in multiple municipalities, implementation of an individual PDCA cycle only may cause isolated optimization. The system for information sharing is critical for implementing a PDCA cycle that can contribute to the optimization of decontamination work as a whole. The governmental organizations that played a central role in the information sharing were the Fukushima Environment Restoration Office for Fukushima Prefecture, Iwate Prefecture and Miyagi Prefecture, and the Kanto Region Environment Office for Tochigi Prefecture, Ibaraki Prefecture, Gunma Prefecture, Chiba Prefecture and Saitama Prefecture.

（2） Improvement of decontamination speed through setting up of temporary storage sites

In order to perform decontamination work smoothly, it is desirable to secure a disposal site for removed soil and other materials generated by decontamination work before starting actual work. There is a limited amount of large land space in Japan that may be used immediately as shown in 1.1.1. If we started decontamination work after we had secured disposal sites for significant amounts of removed soils and other materials, it would take much time and it was clear that the start of decontamination would be delayed.

To solve this problem, we decided to secure so called “temporary storage sites” used to store removed soils and materials temporarily before bringing them to the disposal facility (interim storage facility), to promote the decontamination work, while making efforts to secure the disposal facility.

However, there were many cases in which the setting up of a temporary storage site was not decided easily due to a limited amount of land. Many different efforts were made to set up temporary storage sites.

The reasons why the setting up of temporary storage sites was not advanced easily include the following.

- Difficulty of setting up sites on public lands
  - ✓ There were sufficient areas of national forests[75], and it was not so difficult to form a consensus about making national forests as candidate sites for temporary storage. However, many such forests were preserved as protected forests under the Forest

[75] The area of national forests in Fukushima Prefecture amounts to approximately 400 thousand ha, while the entire area of Fukushima Prefecture is approximately 1 million 400 thousand ha.

Act and the procedures for cancellation of protected forests were required. It took much time to conduct studies and perform cancellation procedures.
- ✓ Since the national forests are located in mountainous areas, we need land reclamation to make them flat. In addition, there are some cases in which preparation and improvement of access roads are required and the disposal of soil from such work also has to be stored. As a result, we could not utilize the area of reclaimed land effectively, and it resulted in taking much time for land reclamation, etc.

- Difficulty in forming consensus with residents living in the vicinity
  - ✓ The residents became angry and felt frustrated, because temporary storage sites were set up not on the premises of TEPCO or national land, but on sites in the vicinity of the residents who were suffering from evacuation and anxieties from radiation. That became a major obstacle to the formation of consensus.
  - ✓ The residents were worried that the temporary storage site might become a final disposal site.
  - ✓ There was a concern that accumulation of soil contaminated with radioactive materials might enhance the impact of radiation.
  - ✓ Residents had a feeling of rejection of storing even contaminated materials that were generated outside their own lands.

To address such problems, the National Government, municipalities and decontamination business operators advanced the following efforts, which led to dispelling the concerns and setting up temporary storage sites by municipalities.

- Seeking candidate lands in the local area
  - ✓ In the case where it was difficult to secure an appropriate temporary storage site within the national land, this fact was communicated honestly to the municipal governments and residents and understanding for securing a temporary storage site in the region was requested. We worked to seek practical solutions jointly with the local community.

- Elimination and mitigation of concerns and frustrations
  - ✓ In response to the opinions that the temporary storage site should be set up within the premises of TEPCO and the national land, we did not turn down such opinions immediately, but explained that it was not practical when looking at it objectively, after considering the practicality of using each premise, and requesting and negotiating with other governmental agencies in some cases. We also worked to eliminate and mitigate frustrations of the residents by making an in-depth explanation that to secure the site in their community would result in advancing decontamination more quickly.
  - ✓ In response to the concerns about the safety of the temporary storage site, we made the following explanations to eliminate and mitigate concerns of the residents: the outmost part would be covered by uncontaminated soil; and accumulated soils would have lower risk once they were accumulated and sufficient safety measures were taken compared to the case in which removed soil was stored on the site.
  - ✓ In addition, there was also an effort to help the residents realize the safety of a temporary storage site through their building a system for monitoring the temporary storage site as in the case of Kawamata Town.
  - ✓ In response to the feeling of rejection of storing contaminated materials that were generated outside their own lands, we explained patiently that setting up the facility would result in advancing decontamination more quickly. Also, we sought the cooperation of heads of district and neighborhood associations, who were closer

to the residents in terms of psychological distance, and asked them to consider setting up a temporary storage site in each administrative district.
  - ✓ In the case of Fukushima Prefecture, in response to the concerns that the temporary storage site might become a disposal facility eventually, the MOE was in the forefront of the efforts to prepare for interim storage facilities as much as possible and to appeal with such an attitude to eliminate and mitigate concerns of the residents.

- Transmission of information on actual status
  - ✓ Since the residents did not have an image of a temporary storage site especially in the initial stage, we worked to create a concrete image of the facility, by providing explanations with leaflets and holding tours on the site of a temporary storage site that was actually set up, in order to reduce psychological resistance against the facility.
  - ✓ Since decontamination work advanced quickly in the areas where the temporary storage site was set up, we made appeals with such results to make the residents recognize the necessity and the importance of the temporary storage site, in order to accelerate the setting up of a temporary storage site also in the areas where the facility had not been set up.

- Flexible response appropriate for the situation of each area
  - ✓ When it was difficult to set up a temporary storage site by any means, we responded in a flexible way according to the situation of each area, such as operation with storage of removed soil and materials on the site, and not sticking to setting up the temporary storage site as an absolute requirement.

Furthermore, we reduced the amount of generated removed soil and materials through avoiding excessive decontamination as mentioned above in the first place in order to reduce the amount of removed soil and materials that were to be brought into the temporary storage site. We also reduced the volume of removed soil and materials by cutting, crushing, compressing or burning them.

1.3.3. Project operation with consideration of the maintenance of community and the protection of rights

（1） Maintenance of community

This decontamination project derived from the 1FNPS accident focused on residents’ returning to their previous lives as early as possible. Therefore, we were required to promote it without damaging the local communities to ensure later life there, not just to remove contaminated soil and materials.

To achieve this goal, we employed a method to perform decontamination work by an administrative unit, such as a district; that is to say “Decontamination of the entire community,” not to advance decontamination work for each related person after obtaining the consent. This decontamination method has a disadvantage for the residents who agreed on performing decontamination work earlier, because it starts after obtaining the consent from all the residents of an administrative unit, such as the district.

Despite such a disadvantage, we needed to promote decontamination work focusing on the local communities that had already existed, given the healthy maintenance of each community after decontamination, in addition to the fact that there was no sufficient decontamination result without decontamination for the whole area.

As to setting up the temporary storage site as shown in Section 1.3.2.(2), many residents said that they agreed to accept the removed contaminated soil from inside their community, but not those from other communities. It can be said that the unit of the local community, such as a district, was one of the important units in Japan to advance decontamination.

This concept was also used in setting evacuation areas. In order to avoid separation of a local community or district, we did not use the annual exposed dose as sole criteria for setting a border of an evacuation area. We were careful so that the border of an evacuation area did not divide a district unit, while making the exposure dose the fundamental criterion.

（2） Protection of rights and consideration of lifestyle

This decontamination project focused on residents' returning to their previous lives as early as possible. Therefore, we did a minimum amount of scraping and replacement of roof materials so as to avoid damages to properties owned by the residents as much as possible. In the case of the residents engaged in farming, the agricultural land was inseparable from their lives: they had cultivated and nurtured their land over a long period of time. Therefore, when a farming family requested it, we tried to select an appropriate decontamination method as much as possible to avoid stripping, etc. and worked to maintain the functions of agricultural soils.

Some residents said, "I want a full replacement." We patiently provided explanations and were committed to protect their properties and agricultural lands that were very important for farming households.

Also, ancestral shrines and garden trees they had grown over years were irreplaceable for the residents' lives. If such shrines and garden trees were removed or cut because they were contaminated, that might cause emotional distress to the residents and lead to degradation of quality of their lives. Therefore, we worked with the residents to coordinate whether decontamination was done or not, as well as choosing the detailed decontamination method based on a comprehensive judgment on the degree of decontamination and the importance for the residents, while listening to their opinions.

（3） Obtaining consent securely

In implementing this decontamination project, we adhered to obtaining consent from the residents before starting decontamination. We were determined not to perform decontamination forcibly, ignoring the intention of the residents.

This was very important not only in terms of the importance of obtaining consent from the residents from a viewpoint of protecting the right of the residents[76] as mentioned in (2) above, because decontamination could damage or change the properties and agricultural lands of the residents, but also in terms of sharing and agreeing on the decontamination plan with the residents, because there were different objectives and methods of decontamination.

Therefore, we obtained the consent of the residents while giving them in-depth explanations and preparing detailed drawings and materials about decontamination procedures for each decontamination objective.

On the other hand, as mentioned above, there are currently several tens of thousands of displaced people from the evacuation area and more than one hundred thousand including those that fled from outside the evacuation area. To obtain residents' consent to decontamination, it is necessary to identify related persons who have the rights over targets of decontamination and obtain consent regardless of whether they are living there or have evacuated the area. However, there are a great number of decontamination targets: the number of residences to be covered by decontamination solely amounts to from several tens of thousands to several hundred thousand. Especially for the Special Decontamination Areas, where all the residents have evacuated, we need to identify the number of related persons by checking with registry books and other materials, then identify where they have evacuated to and explain the current situation and the method of decontamination to them to obtain consent. Also, in the case that one person owns multiple land plots or buildings, name-base aggregation is required to organize the data. As a result, a great amount of manpower was required to obtain their consent.

Moreover, we could not always obtain the consent after a one-time explanation/discussion. There were many cases in which we finally obtained the consent after we had listened carefully to the

[76] In addition to obtaining consent from residents on the possibility of damages to their properties in the process of implementation of agreed-on decontamination methods, we needed to agree on the conditions of their properties before decontamination so that we could confirm whether damages and loss discovered after decontamination had been caused by decontamination work or not.

requests of the residents, considered such requests and answered their questions again and again.

Especially in the Special Decontamination Areas from where the residents had already evacuated, it was more difficult to obtain the consent, because the residents could not confirm whether there was any inappropriate decontamination work or damage to the buildings for themselves. Therefore, we confirmed their consent on the site and allowed them to be present at the decontamination to observe decontamination work so that the residents could confirm the work with their own eyes. We also provided instruction and education to decontamination business operators and workers, who would obtain the consent from related persons, to respond to such persons sincerely so that they could build a relationship of trust with them.

Although those efforts were made, the degree of consent varied by individual and by area. As a result, the progress of decontamination varied by area, and the areas in which decontamination was underway and those in which it was not were distributed in a patchy fashion.

1.3.4. Careful response with consideration for residents' position and feelings

Anxieties and concerns of the local residents are not always related to decontamination. Especially in the Special Decontamination Area, the residents did not necessarily have a positive attitude toward discussing decontamination solely, because the review of the area that served as a base for the decontamination plan was related to the compensation criteria. Therefore, we made careful responses giving thought to situations and feelings of residents of the area, such as bringing staff members who could provide explanations about the review of the area and compensation when we had a briefing session about decontamination.

Also, the residents had a feeling of non-acceptance toward effluent water, as they had an image that contamination was also transferred when water flowed from the premises of their residences to outside, although it was unlikely that effluent water generated as a result of decontamination in the Intensive Contamination Survey Area had a higher level of radioactive concentration. Therefore, we took necessary measures in response to the request of the residents, such as recovery of effluent water.

Furthermore, we also gave consideration to their feelings about visiting their residences: In the seasons when there were many requests for overnight stay, such as the year-end and New Year holidays and the Bon period for visiting their ancestors' graves, we also conducted decontamination prior to these periods.

In addition, the fact that many decontamination workers come to the community from outside means an increase of strangers in the community to the local residents, and they are likely to be concerned about the change of the community's atmosphere, deterioration of public security and generation of traffic jams. To address such concerns, we made many efforts to build a relationship of trust between the local residents and the decontamination workers.

2. Overview of decontamination methods

As explained in the previous chapter, the Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District Off the Pacific Ocean Earthquake That Occurred on 11 March 2011 (hereafter referred to as the "Act on Special Measures") designated the Special Decontamination Areas for the National Government to decontaminate and the Intensive Contamination Survey Areas for the local municipalities to decontaminate. In order to achieve the additional exposure dose of 1 mSv/y or less as the long-term goal, the decontamination was planned to be implemented in the following order.

(i) Investigate and measure the status of contamination and designate the areas in which decontamination and other measures are to be implemented (Articles 34 and 36)
(ii) Formulate the decontamination plan and implement decontamination based on the plan (Article 40)
(iii) Collect, transfer and store the removed soil, generated by the decontamination and related works (Article 41)

The Ministry of the Environment (MOE) formulated the "Decontamination Guidelines (1st Edition)" in December 2011 to explain these processes in a concrete manner. The guidelines are divided into the following four parts and each part corresponds to one of the above (i) to (iii).

- Part 1: Guidelines for the Methods for Investigation and Measurement of the Status of Environment Pollution in the Intensive Contamination Survey Areas (corresponding to (i))
- Part 2: Guidelines Pertaining to Decontamination and Other Measures (corresponding to (ii))
- Part 3: Guidelines Pertaining to the Collection and Transfer of Removed Soil (corresponding to (iii))
- Part 4: Guidelines Pertaining to the Storage of Removed Soil (corresponding to (iii))

While the guidelines mainly cover the decontamination by municipalities, they also cover decontamination by the National Government. Decontamination in accordance with these guidelines is deemed to be appropriate for the situations found in Japan.

The guidelines were revised in May 2013. Further, a supplement was added in December 2014 based on the opinions of specialists and local governments and it included the responses to improper decontamination, ways for conducting more effective decontamination, as well as giving the knowledge obtained and the new technologies made available since December 2011.

The four parts are outlined and explained below based on the revised 2nd Edition[77].

2.1. Guidelines for Methods for Investigation and Measurement of the Status of Environmental Pollution in the Intensive Contamination Survey Area

2.1.1. Basic Concept

The "Guidelines for Methods for Investigation and Measurement of the Status of Environmental Pollution in Intensive Contamination Survey Areas" corresponds to Part 1 of the Decontamination Guidelines. As shown in Figure 2-1, this part explains the following items: (i) the investigation and measurement of the status of environmental pollution by the accident-derived radioactive materials in the Intensive Contamination Survey Areas; (ii)

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[77] Source: Ministry of the environment (MOE), "Decontamination Guidelines (2nd Edition)" (supplement added, December 2014) (http://josen.env.go.jp/material/pdf/josen-gl-full_ver2_supplement1412.pdf) Fig.2-1 to Fig.2-41 and Table 2-1 to Table 2-57 are from the same source.

details of the measurement methods necessary for decontamination and related works, and storage of removed soil in the decontamination implemented areas; and (iii) the methods for determining accuracy of measurement.

Measurements are needed to determine the appropriate decontamination measures and to monitor storage sites of removed soil as mentioned above, and in this context they also relate to other parts of the Decontamination Guidelines. This correlation is illustrated in Figure 2-2.

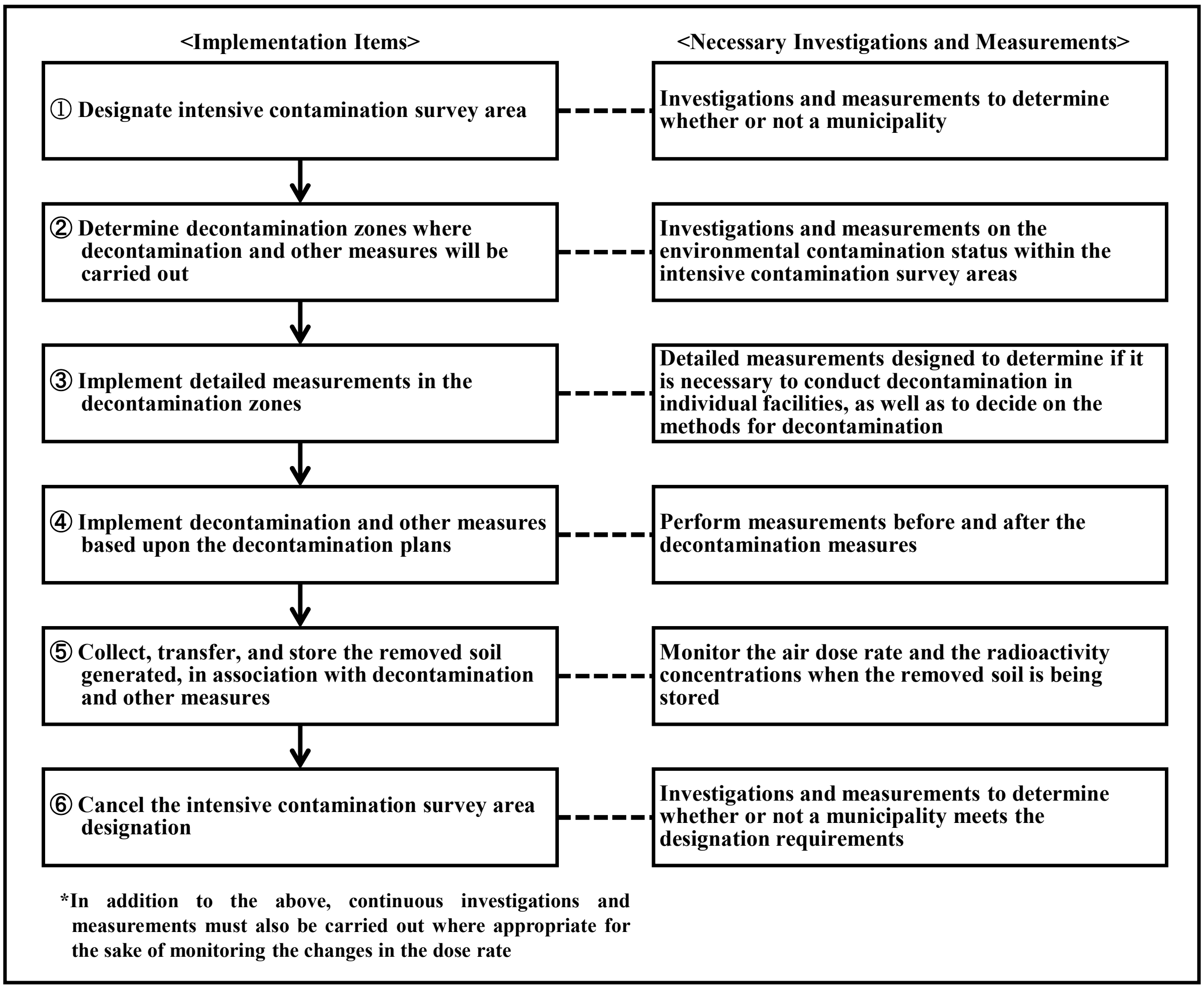
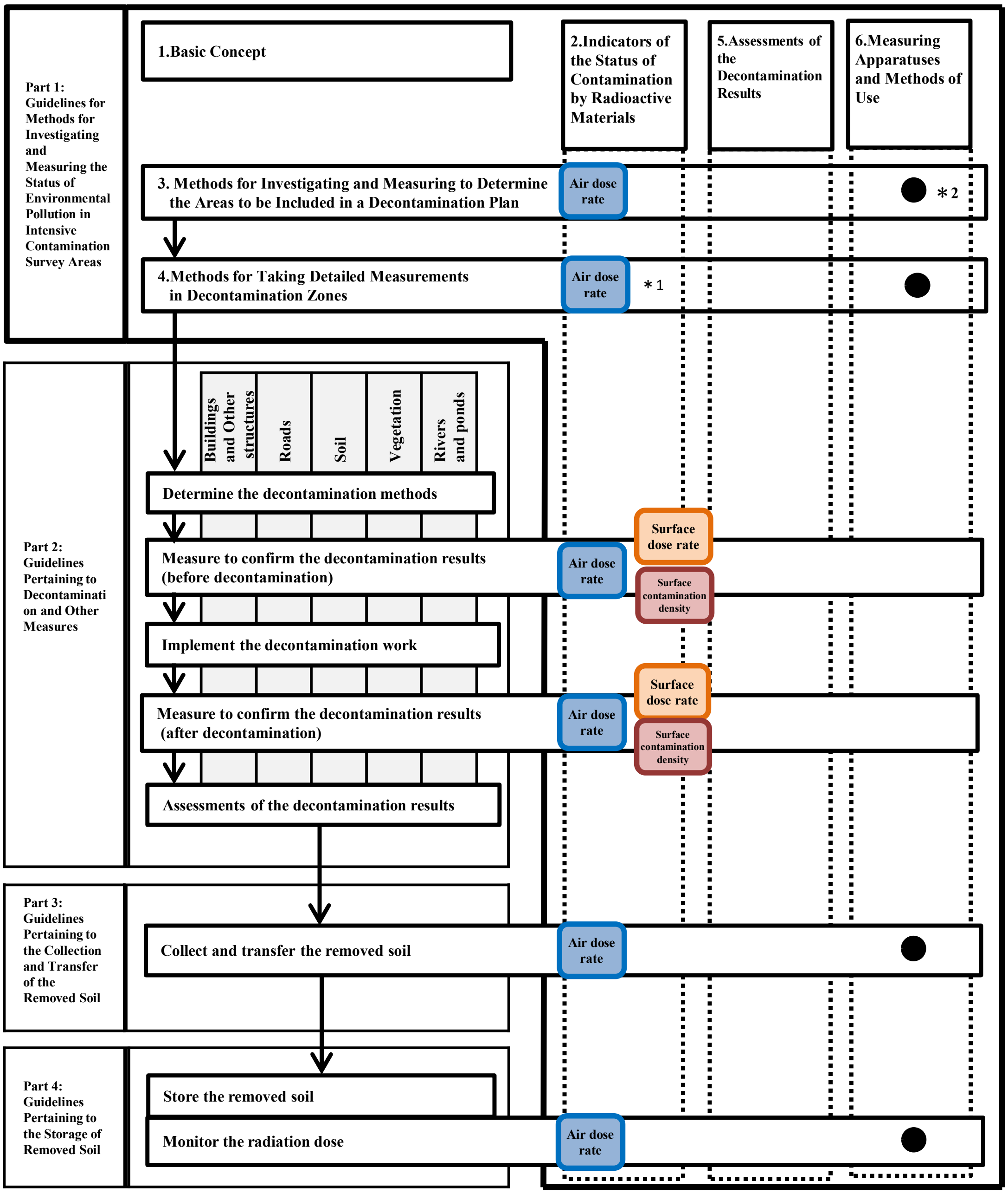


Figure 2-1 Implementation items and necessary investigations and measurements for carrying out decontamination.



*1: If "4. Detailed Measurements in Decontamination Zones" concurrently serve as "Measure to confirm the decontamination results (before decontamination)", then measurements of surface dose rate and surface contamination density shall also be performed.

*2: Those parts related to "5. Assessments of the Decontamination Results" and "6. Measuring Apparatuses and Methods of Use" are indicated with a "● "

Figure 2-2 Descriptive actions related to measurements in the Decontamination Guidelines

2.1.2. Indicators of the Contamination Status by Radioactive Materials

The indicators of the contamination status by radioactive materials use the air dose rates as the indicators of the contamination status in the living environment and the surface contamination densities and surface dose rates as the indicators of the contamination status of the objects subject to decontamination in order to grasp the contamination status by radioactive materials. Table 2-1 summarizes the indicators together with measurement methods.

Table 2-1 Summary of indicators of the contamination status by radioactive materials

<table>
<tr><td>Assessment perspectives</td><td>Status of contamination in living spaces</td><td colspan="3">Status of contamination of objects subject to decontamination</td></tr>
<tr><td>category</td><td>No. 1 measurement points(①)</td><td colspan="3">No. 2 measurements points(②)</td></tr>
<tr><td>Measurement objective</td><td>• Determine the decisions of decontamination zones
• Determine if it is necessary to conduct decontamination within individual facilities in the decontamination zones through detailed measurements in the zones(determine by using mean dose rate)
• Determine the comprehensive results of the decontamination within the individual facilities from the decontamination and other measures (however, attention must be paid to the fact that this is affected by background radiation*3)
• Monitor the radiation dose when the removed soil is stored</td><td colspan="3">• Determine the scope for the decontamination in individual facilities and determine the amount of radioactive materials (extent of the contamination) in conjunction with the detailed measurements carried out within the decontamination zones
• Confirm the degree to which the contamination of the objects subject to decontamination has abated due to the decontamination and other measures</td></tr>
<tr><td rowspan="2">Indicator (measurement position)</td><td rowspan="2">Air dose rate (1 m*1)</td><td rowspan="2">Surface contamination density (1 cm)</td><td colspan="2">Surface dose rate (1 cm)</td></tr>
<tr><td>Use a collimator</td><td>Vary the distance and measure*2</td></tr>
<tr><td>Examples of measuring apparatus</td><td>• NaI scintillation survey meter
• CsI scintillation survey meter</td><td>GM survey meter</td><td colspan="2">• NaI scintillation survey meter
• CsI scintillation survey meter</td></tr>
<tr><td>Methods for using the measurement results</td><td>• Determine the decontamination zones
• Assess the improvements in the contamination status in living spaces through the decontamination work</td><td colspan="3">• Determine the decontamination methods
• Assess the extent to which the radioactive materials have abated through the decontamination work</td></tr>
</table>

*1: For the contamination status in living spaces, in principle, measurements should be taken at a height of 1 m from the ground (it would also be fine to measure at a height of 50 cm at elementary and lower level schools, as well as special-needs schools, with consideration for the living spaces of infants and schoolchildren in the lower grades).

*2: The surface dose rate of the target object is to be measured at positions at the object's surface and at heights of 50 cm and 1 m, and then the measured values are to be compared.

2.1.3. Methods for Investigation and Measurement to Determine the Areas to be Included in a Decontamination Plan

（1） Basic concept

The methods for investigation and measurement to determine the areas to be included in the decontamination plan stipulate that the decontamination areas (areas to be included in a decontamination plan) are in principle divided by the unit of zones such as an a village section, a municipal block, or other units, where the dose rate is 0.23 μSv/hour[78] or higher, which is the condition for decontamination planning. But regarding the living environment for children, such as schools and parks, it is allowed to divide the decontamination zones based on each facility rather than on an area such as municipal blocks.

（2） Methods for investigation and measurements by zone units

The methods for investigation and measurements by zone units are used to judge whether a zone meets the decontamination planning requirements and then to select suitable measurement methods based on the judgement. Two examples are given. The first is based on the measurement results at various points (Figure 2-3) and the second is based on the measurement results at schools and in parks (Figure 2-4).

1）Designation based on the measurement results at various points

- Specific locations and number of points for measurement in a zone are first chosen in consideration of the following points, depending on the form of existing land use and the situation of the surrounding.
  - ✓ The locations of measurement are chosen in a manner that the general tendency in the zone can be represented.
  - ✓ Special locations such as the base area of trees, street drains and other locations where high dose rates may be recognized should not be chosen, because the measurements are intended to grasp the average dose rate in the zone.
  - ✓ More locations should be chosen in a living space where, for instance, there are many buildings.
  - ✓ Investigations and measurements may not always be needed in zones where people's exposure dose cannot be naturally reduced, such as forests.
  - ✓ Efficient investigations and measurements should be employed as needed, for example, measurements by using monitoring vehicles.
- Once the measurements are completed at all points in the zone, the average dose rate of the zone is calculated based on all the results of the zone.
- Based on the average dose rate, the judgment is derived whether that zone meets the decontamination planning requirements.

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[78]The air dose rate per hour which is equivalent to the additional annual exposure dose per year of 1 mSv. This is calculated as follows: 0.19 μSv/h×（8 h＋0.4×16 h）×365 days= 1 mSv per year. The dose rate of 0.4 μSv/h due to exposure from the ground is added to 0.19 μSv/h and then air dose rate per hour of 0.23 μSv is obtained. (Refer to "Basis of the additional annual exposure dose of 1 mSv per year" (October 10, 2011): The first joint review meeting of the environment restoration review committee and the hazardous waste safety evaluation review committee.)

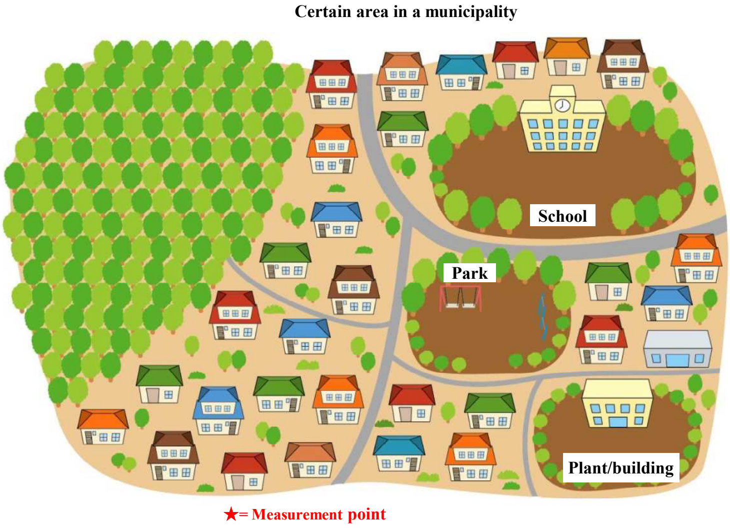


Figure 2-3 Example of the determination of whether the area meets the decontamination planning requirements based on the measurement results at various points.

2）Designation based on the measurement results at schools and in parks

- Specific locations and number of points for measurement in a zone are first chosen in consideration of the following points.
  - ✓ Measurements are to be made mainly in the living environment of children, such as schools and parks in the zone.
  - ✓ Special locations such as the base area of trees, street drains and other locations where high dose rates may be recognized should not be chosen, because the measurements are intended to grasp the average dose rate in the zone.
  - ✓ Measurements are to be done at about five points in each school or park.
- Once the measurements are completed at all points in the zone, the average dose rate of the zone is calculated based on all the results of the zone.
- Based on the average dose rate, the judgment is derived whether that zone meets the decontamination planning requirements

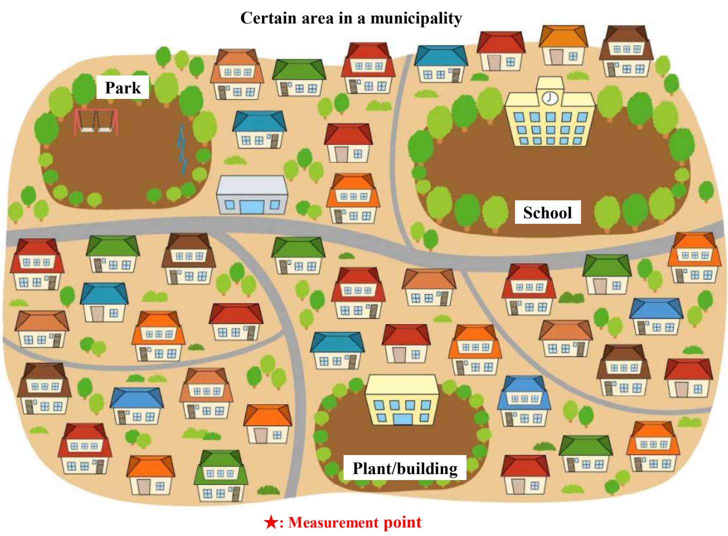


Figure 2-4 Example of the determination of whether the municipal area meets the decontamination planning requirements based on the measurement results for schools and parks.

(3) Methods for investigation and measurement of the living environment of children, such as schools and parks

Concerning the living environment for children such as schools and parks, it is allowed to designate a decontamination planning zone on a facility basis, as mentioned in (1) above. This subsection presents the decision criteria to judge whether each facility (zone) meets the planning requirements (Figure 2-5).

- Specific locations and number of points for measurement in a facility are first chosen in consideration of the following points.
  - ✓ Special locations such as the base area of trees, street drains and other locations where high dose rates may be recognized should not be chosen, because the measurements are intended to grasp the average dose rate in the facility.
  - ✓ Measurements are to be done at about five points in each facility.
- Once the measurements are completed at all points in the facility, the average dose rate of the facility is calculated based on all the results of the facility.
- Based on the average dose rate, the judgment is made whether that facility meets the decontamination planning requirements.

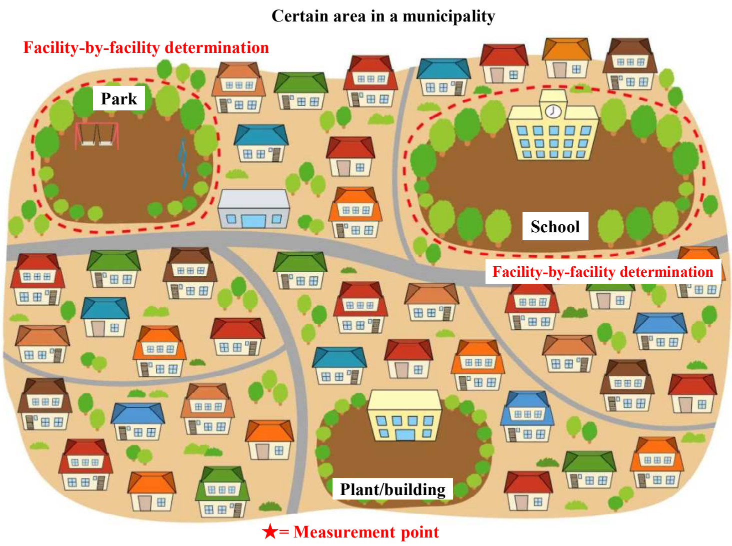


Figure 2-5 Example of the determination of whether the area meets the decontamination planning requirements based on the measurement results only from facilities used by children, such as schools and parks.

2.1.4. Methods for Taking Detailed Measurements in Decontamination Zones

The methods for detailed measurements in decontamination zones elaborates on the things to record in the measurements in detail. It also stipulates that the detailed measurements be included as part of the pre-decontamination work measurements.

The locations to be decontaminated and decontamination methods are described in Section 2.2, “Guidelines Pertaining to Decontamination and Other Measures”, and are not explained here.

2.1.5. Evaluation of Decontamination Results

The evaluation of decontamination results stipulates that the decontamination results can largely be evaluated by two ways: evaluation of air dose rates in the living environments in the decontamination zone as a whole and the individual targeted facilities; and evaluation of surface concentration densities of the objects subject to decontamination in the individual decontamination works. The former evaluation is expressed in terms of reduction rate of the air dose rate, while the latter evaluation may be expressed in terms of decontamination factor (DF) as well as the reduction rate.

Reduction rate [%] = (1- Radiation dose after decontamination ／Radiation dose before decontamination)×100

Decontamination factor [-] = Surface contamination density before decontamination／Surface contamination density after decontamination

2.1.6. Measuring Devices and Methods of Use

The measuring devices and methods of use explains the measurements necessary for the whole scope of activities covered by the Decontamination Guidelines, including not only the measurements for formulating decontamination plans but also measurements for confirming the results of radiation reduction through the decontamination works and other relevant measurements.

(1) Measuring devices and methods of use

Among the measuring devices and methods of use, scintillation survey meters (scintillation counters) are used for dose rate measurement and GM survey meters (GM counters) are used for surface contamination density measurement.

(2) Maintenance of measuring devices

Regarding maintenance of measuring devices, users should note that the measuring devices may give incorrect readings for such reasons as changes in the sensitivity of detectors caused by the measuring environment or degradation of any components in the electrical circuit. It is stressed that the measuring devices should be periodically calibrated and adjusted.

(3) Methods of use of measuring devices

The methods of use of measuring devices identifies the precautions to be taken for measurements using scintillation survey meters and GM survey meters, as summarized in Table 2-2. Furthermore, examples of the format of recording sheets for measurements are presented in Figure 2-6 and Figure 2-7.

Table 2-2 Summary of measuring devices and methods of use

<table>
<tr><td>Category</td><td>No. 1 measurement point (①)</td><td colspan="2">No. 2 measurement point (②)</td></tr>
<tr><td>Purpose of measurements</td><td>Contamination status of living spaces</td><td colspan="2">Contamination status of objects subject to decontamination</td></tr>
<tr><td>Object measured</td><td>Gamma rays</td><td>Gamma rays</td><td>Beta rays</td></tr>
<tr><td>Examples of measuring apparatuses</td><td colspan="2">• NaI scintillation survey meter
• CsI scintillation survey meter</td><td>GM survey meter</td></tr>
<tr><td>Calibration</td><td colspan="3">• Measuring apparatuses shall be calibrated at least once a year in accordance with JIS.(Agent performing the calibration work)
• Businesses registered in accordance with the Measurement Act
• Measuring apparatus manufacturer</td></tr>
<tr><td>Daily check</td><td colspan="3">• The remaining battery level, breakage of cables and connectors, and status of high voltage application shall be checked, and inspections of switch operability, etc. shall be carried out.
• Measurements shall be performed at the same places where the background radiation does not vary substantially, and it shall be confirmed that there are no large variations by comparing with past values.
• If it is difficult to perform the calibrations more than once a year as described in the above section, this can be substituted by a method (adjustment) to compare the results with those obtained in the same location where measurements were also taken by using a separate measuring apparatus that has been fully calibrated and checked (this excludes GM survey meters).</td></tr>
<tr><td>Prevention of contamination</td><td colspan="3">• The body and detecting element of the measuring apparatus shall be preferably covered with a thin plastic sheet, etc.
• The plastic sheet, etc. shall be replaced with new material when it gets dirty or breaks.</td></tr>
<tr><td>Measurement</td><td>• The air dose rate shall be measured at a height of 1 m from the ground.
• The air dose rates on roads and pedestrian overpasses near schools may be measured at a height of 50 cm from the ground for elementary schools and below, as well as special-needs schools, with consideration for the living space of infants and schoolchildren in the
• Lower grades.</td><td>[Using a collimator]
• The air dose rate shall be measured at a height of roughly 1 cm (a height where about one finger will fit between the detector element and the measurement point) from the surface of the measurement point while using a collimator to shield against external gamma rays.
[Measurements by varying the distance]
• The air dose rate shall be measured from</td><td>• Measurements shall only be taken roughly1 cm away from the surface.</td></tr>
</table>

		positions on the surface and at heights of 50 cm and 1 m away from it, and the measured values shall be compared.	
	• Prior to measurement, it shall be confirmed whether the background value of the measuring apparatus is being displayed abnormally (no indicators appear, or indicators are unusually high or low). • When measuring the air dose rate, the measurements shall be taken with the detecting element parallel to the ground surface and as far away as possible from the body. • The power to the measuring apparatus shall be turned on and the reading (measured value) shall be read off after waiting until the reading stabilizes. In doing so, with measuring apparatuses on which a time constant can be set, the measurer shall wait until a period of time that is three times longer than the time constant has elapsed before performing the measurements. • If the readings on the measuring apparatus disappear, switch the range and take the measurements, and if the readings disappear in the maximum range, either interpret those readings as being in the maximum range or higher, or use another type of measuring apparatus to take the measurements. • If readings vary, the average value shall be read.		
Records	The measurer shall record the air dose rate, etc. at each measurement point shown in the conceptual diagram, etc., along with the date and time of measurement and the measuring apparatus used (see Figures 1-14 through 1-18).		

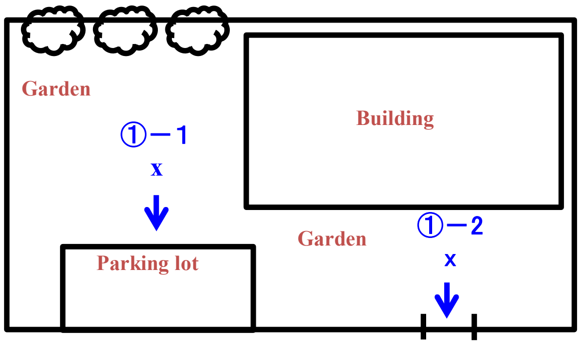
Manufacturer: Mode	City: Town: District:
Measuring apparatus	Manufacturer: Model:

Measurement Status Entry Column		
	Before Decontamination	After Decontamination
Date measured	Mon., April 22, 2013	Fri., April 26, 2013
Time measured	9:20~9:40	13:20~13:40
Measurer	Josen Taro	Josen Taro
Weather	Cloudy	Clea

Air Dose Rate Measurement Results Entry Section						
	Before Decontamination		Measurement height	After Decontamination		Measurement height
①-1 measurement point	3.0	μSv/h	(1m) 50cm	0.51	μSv/h	(1m) 50cm
①-2 measurement point	0.55	μSv/h	(1m) 50cm	0.16	μSv/h	(1m) 50cm
①-3 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
①-4 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
①-5 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
①-6 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
①-7 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
①-8 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
①-9 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
①-10 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
Notes						

Schematic Diagram of Air Dose Rate Measurement Points

(Example)



*The arrows indicate the direction of the measurements.

Figure 2-6 Entry sample of an air dose rate record sheet.

Manufacturer: Mode	**City: Town: District:**
Measuring apparatus	**Manufacturer: Model:**

Measurement Status Entry Column		
	Before Decontamination	**After Decontamination**
Date measured	**Day: ( ) Month: Year**	**Day: ( ) Month: Year**
Time measured		
Measurer		
Weather		

Air Dose Rate Measurement Results Entry Section						
	Before Decontamination		**Collimator**	**After Decontamination**		**Collimator**
①-1 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
①-2 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
①-3 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
①-4 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
①-5 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
①-6 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
①-7 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
①-8 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
①-9 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
①-10 measurement point		**cpm**	**Yes No**		**cpm**	**Yes No**
Notes						

Schematic Diagram of Air Dose Rate Measurement Points

Figure 2-7 Example of a surface contamination density record sheet.

2.2. Guidelines Pertaining to Decontamination and Other Measures

2.2.1. Basic Concept

(1) Role of the Guidelines

The Decontamination Guidelines use example cases to explain in a concrete fashion the Ordinance of the Ministry of the Environment (MOE) pertaining to standards for the measures for decontamination of the soil, etc. provided in Article 40, Paragraph 1 of the Act on

Special Measures.

Each municipality will formulate a decontamination plan based on prioritization and feasibility in light of the actual conditions in individual areas. Appropriate decontamination methods will be selected as needed from among those listed in these guidelines to advance the decontamination work based on individual decontamination plans.

At present, the methods given in these guidelines are deemed to be appropriate for implementing decontamination and related procedures, but decontamination work and new technologies are currently being developed and verified by various stakeholders. These guidelines will be revised as needed in light of trends in the development and verification of this knowledge and these technologies.

(2) Important points in implementing decontamination and other measures

This section explains the four aspects that are important in implementing decontamination measures. The radioactivity of radioactive materials decays naturally as time passes. In addition, the appropriate responses must be taken by fully considering the changes in the contamination status as a result of factors like the radioactive materials migrating due to rainwater and other factors.

- Measures shall be taken to prevent dispersion and outflow, as well as offensive odors, noise, and vibrations, and records of the quantities of removed soil and other necessary measures should be taken with respect to preserving of health of surrounding residents and conserving the living environment.
- To effectively reduce the radiation doses due to contamination, those locations that are contaminated at comparatively high concentrations that contribute substantially to the radiation dose must be identified, and appropriate methods of decontamination must be used in accordance with the characteristics of the contamination. The effectiveness of these methods must also be confirmed by measurements before and after the decontamination to effectively reduce the radiation doses in the living environment.
- The removed soil, etc. must be separated from other objects to ensure that there is no danger that it mixes with other objects, and the removed soil must also be separated from other decontamination wastes to the extent possible.
- It is important to strive to minimize the quantity of removed soil, etc. generated during decontamination. It is also important to ensure that the contamination does not spread as a result of the decontamination work. For example, washing activities using water produce drainage that contains radioactive materials. The workers carrying out decontamination and other measures should, to the extent possible, remove in advance those radioactive materials that can be removed by methods other than washing with water, properly treat wastewater, and find other ways to avoid affecting outflow destinations due to cleaning, etc. as much as possible. Moreover, periodic monitoring should be performed after the applicable measures are implemented when deemed necessary on account of the actual conditions in the area.

2.2.2. Decontamination and Other Measures for Buildings and Other Structures

This section explains preparation, prior measurements, decontamination methods, post-work measures, and subsequent measurements and records, as shown in Figure 2-8 of the basic flow pertaining to decontamination and other measures for houses, buildings, agricultural facilities, and other structures.

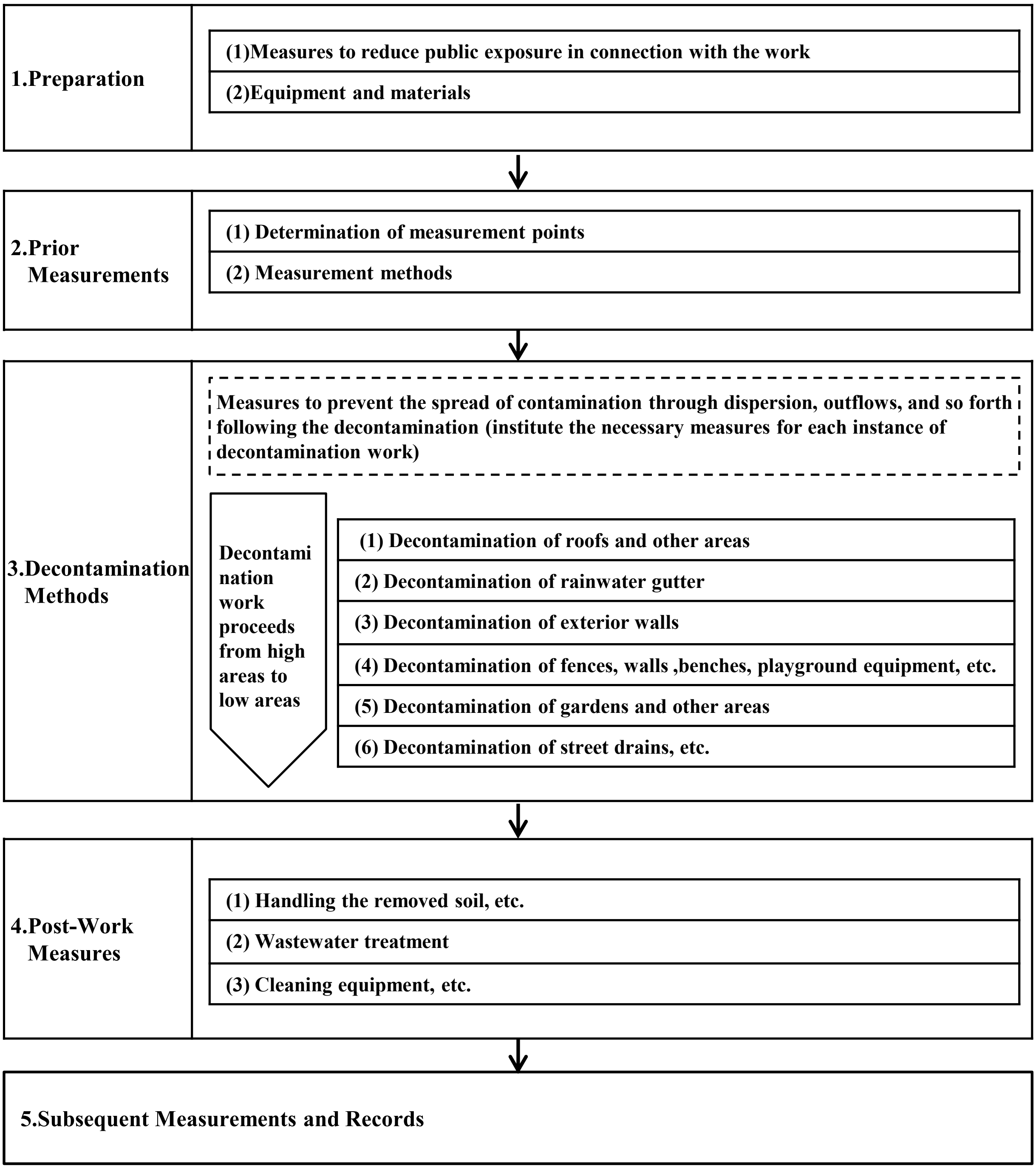


Figure 2-8 Basic flow for decontamination and other measures for buildings and other structures.

(1) Preparation

Before performing decontamination work, in addition to preparing the equipment required for the work, preparations must be made to ensure safety of workers and the general public to prevent their exposure to hazards, such as by inhaling dust generated during decontamination work; these preparations are summarized in Table 2-3.

Table 2-3 Preparation for decontamination and other measures

Measures to Reduce Public Exposure in Connection with Decontamination Work	Restriction of entry	• In cases where the general public is deemed likely to enter the area, the area shall be cordoned off with pylons or rope, etc. to prevent people from unnecessarily approaching the work site, and the entry of people and vehicles shall be restricted • In cases where radioactive materials may be dispersed in connection with the decontamination work, the perimeter of the decontamination area shall be fenced in with sheets, etc., water shall be sprayed, or other such measures shall be taken to prevent dispersion and the area shall be cordoned off with rope, etc.
	Signage	• In cases where the general public is deemed likely to enter the area, signs, etc. shall be put up to alert the public that decontamination work is being performed.
Preparation of Equipment and Materials Preparation of Equipment and Materials	General equipment	Examples : Mower, hand shovel, grass sickle, broom, bamboo-rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags)), vehicles for transporting collected removed soil, etc. to the on-site storage location (truck, two-wheeled cart, etc.), ladder
	Equipment for cleaning with water	Examples : Hose, shower nozzle, high pressure water cleaner, brushes (scrub brush, brush for cleaning vehicles, brush for cleaning high places), scrubbing brushes (circular scrubber, steel wool brush, etc.), wire brushes, tools for pushing away water (broom, scraper, etc.), bucket, detergent, dust cloth, sponges, paper towels
	Equipment for cleaning metal surfaces	Examples : Brush, sandpaper, cloth, removing agents
	Equipment for cleaning wood surfaces	Examples : Brush, sandpaper, power sander, cloth, steam cleaner, water high pressure washer, tools for pushing away water (broom, scraper, etc.)
	Equipment for work in high places	Examples : Scaffold, mobile lift, aerial vehicle
	General equipment	Examples : Mower, hand shovel, grass sickle, broom, bamboo rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags)), vehicles for transporting collected removed soil, etc. to the on-site storage location (truck, two-wheeled cart, etc.), ladder
	Equipment for cleaning with water	Examples : Hose, shower nozzle, high pressure water cleaner, brushes (scrub brush, brush for cleaning vehicles, brush for cleaning high places), scrubbing brushes (circular scrubber, steel wool brush, etc.), wire brushes, tools for pushing away water (broom, scraper, etc.), bucket, detergent, dust cloth, sponges, paper towels

(2) Prior measurements

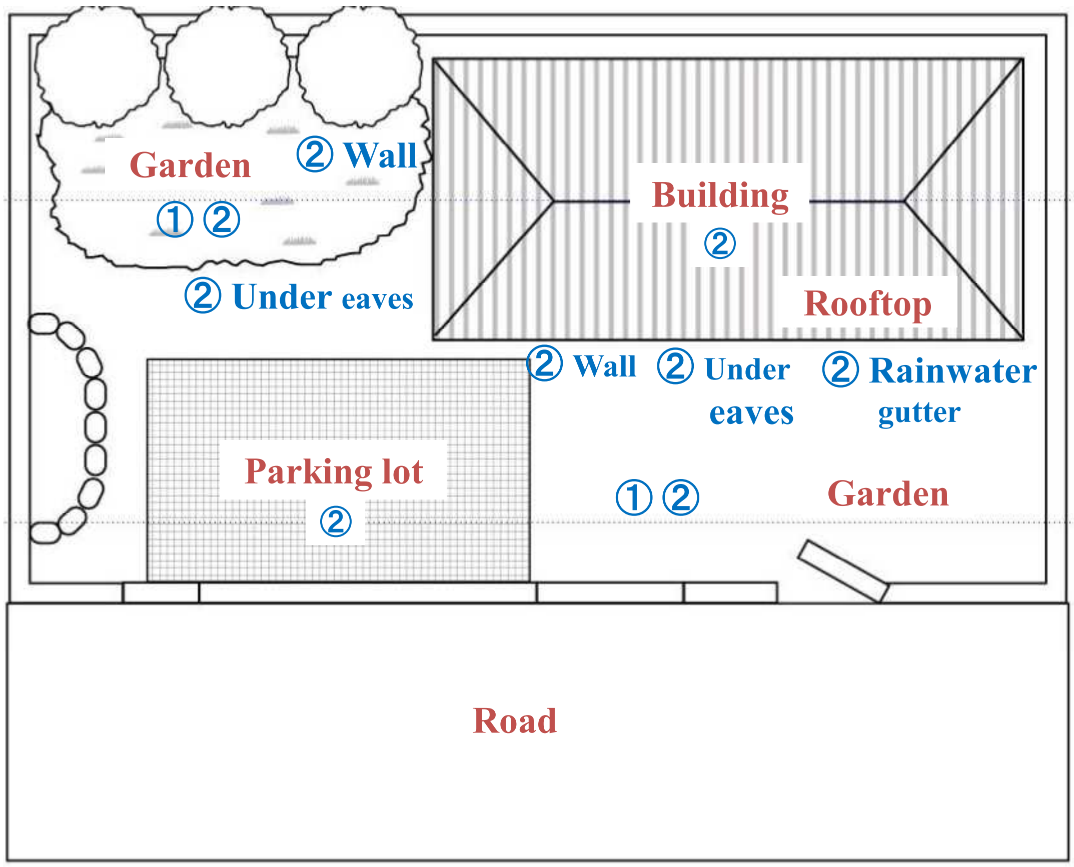
The air dose rate, etc. should be measured and recorded at the same location and by the same method both before and after decontamination work in order to confirm decontamination effects. The method of measurement for the air dose rate, etc. before decontamination work is explained below.

1) Determination of measurement points

Before decontamination work, determining the location where the air dose rate, etc. is measured (thereafter refer to as "measurement point"; Table 2-4) and preparing a diagram (Figure 2-9) with the areas to be measured, are done, and the structures to be used as markers, etc., are described and diagram examples are presented. In addition, it is explained that hotspots and their ambient areas can be excluded from the measurement points, if the residents are not expected to stay there for a relatively long time

Table 2-4 Reasoning behind the measurement points for air dose rates and other measures for the decontamination of buildings and other structures

Measurement point	No. 1 measurement points(①)	No. 2 measurement points (②)
Measurement target	Air dose rate in living spaces	Surface contamination density, etc. for objects subject to decontamination
Reasoning behind the measurement points	• For detached housing, in gardens and other outdoor locations, approximately two to five measurement points shall be set from among places where people are deemed likely to spend relatively large amounts of time. • For collective housing, public facilities, and so forth, in gardens and other outdoor locations, approximately five measurement points shall be set from among places where people are deemed likely to spend relatively large amounts of time.	• Measurement points for roofs, rooftops, and the sides of buildings shall be set near the center of each surface. • Measurement points for gardens and other grounds shall be set near their centers. (Choose places along the centerline for grounds that are long and thin or otherwise not square.) • Measurement points for fences and walls shall be set at intervals that enable the distribution of the air dose rate, etc. to be ascertained.[Example] Pitch of 5 to 10 m • Measurement points for benches, playground equipment, etc. shall be set at places people will be in contact with.



①:Contamination status for living spaces
(air dose rate: approximately two to five measurement points)

②:Contamination status for objects subject to decontamination
(surface contamination density, surface dose rate)

Figure 2-9 Example schematic diagram for reporting measurement points for use in decontamination and other measures for buildings and other structures.

2) Measuring methods

It is recommended that for the measurement point marked as ① the apparatuses such as NaI scintillation survey meters which are able to measure gamma rays should be used and for the measurement point marked as ② GM survey meters should be used.

(3) Decontamination methods

The flow of overall decontamination work is shown in Figure 2-10; basic features include implementing decontamination work from higher locations to lower locations and preventing contamination from spreading or being released. Individual decontamination measures for roofs, rainwater gutters, exterior walls, fences, ditches, gardens, street drains, etc. are described in terms of the items such as basic flow, necessary measures for prior decontamination work and decontamination methods and notes of caution.

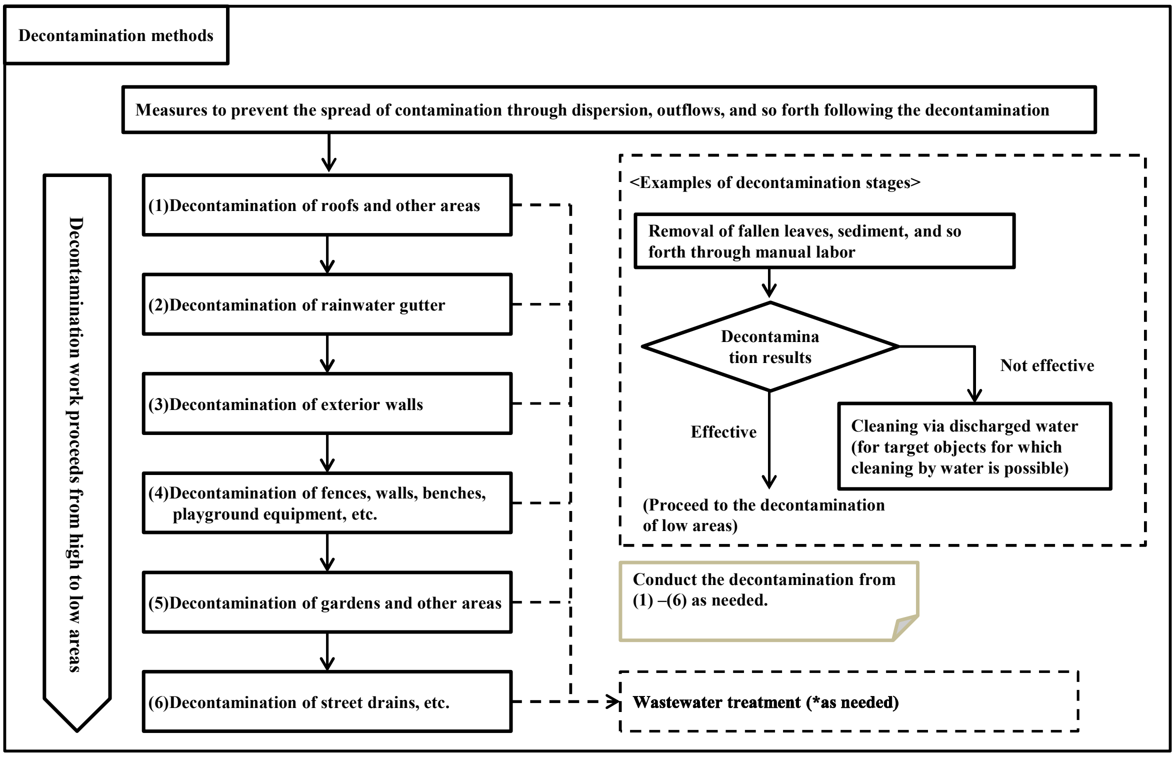


Figure 2-10 Basic flow for the decontamination of buildings and other structures.

1) Decontamination of roofs

The flow of decontamination for roofs is shown in Figure 2-11. The necessary measures prior to the decontamination work are shown in Table 2-5. The decontamination methods are shown in Table 2-6.

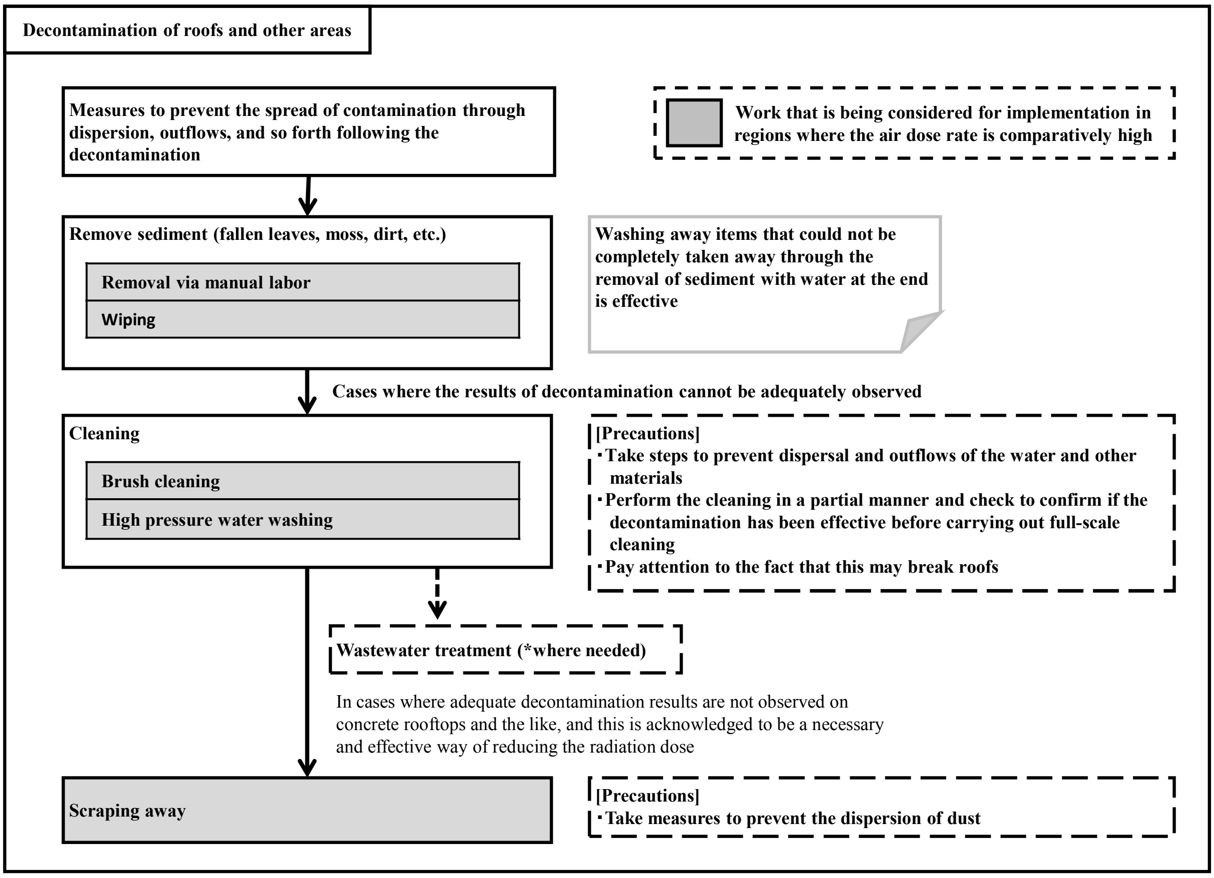


Figure 2-11 Basic flow for the decontamination of roofs and other areas.

Table 2-5 Necessary measures prior to the decontamination of roofs and other areas

Category	Decontamination methods and notes of caution
Safety measures	• When performing work in high places, appropriate safety measures shall be taken, such as erecting scaffolding and allocating aerial vehicles.
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc. • Using a method of water recovery-type high pressure water cleaning is also effective for preventing the dispersal of radioactive materials.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater.

Table 2-6 Decontamination methods for roofs and other areas and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Decontamination through manual labor	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
	Wiping	• Wiping shall be performed carefully through the use of paper towels or dust cloths that have been dampened with water. • All sides of folded paper towels, dust cloths, etc. used in wiping work shall be used. However, none of the surfaces that have already been used for decontamination (wiping) shall be touched with bare hands as these surfaces may have radiocaesium on them. • Consideration shall be given to preventing the contamination from re-adhering by such means as wiping it down with a new side of the cloth for each wipe according to the contamination status. • In some cases the results of the decontamination will be smaller due to effects from roofing materials like cement tiles, matte clay tiles, and painted steel sheets, as well as from rust. • When rust is present, the rust itself must be removed by being wiped away.
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using scrub brushes, scrubbing brushes, etc. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings. • Rotary brushes shall not be used as they are not suitable for thatched or tiled roofs.
	High pressure water cleaning	• Any possibility of breakage or damage to roofs, etc. from high pressure water cleaning shall be checked in advance (obtaining advice from a specialist is recommended). • To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • To achieve a decontamination effect, the spray nozzle shall be brought near the place to be decontaminated. • Special attention shall be paid to cleaning the overlapping sections
Scraping away	Blast work	• Abrasive materials shall be shot at the surface with a shot blaster and scraped away from said surface uniformly. • In order to prevent dust from arising, curing, etc. shall be performed to prevent dispersion of dust to the surroundings and the dust shall be collected. • For blast work, curing shall be performed to ensure that abrasive materials and the like do not travel outside of the decontamination work area. What is more, after the abrasive materials and other materials have been used they shall be collected in a manner that ensures that they will not scatter the radioactive materials adhering to them to the surroundings.
	Scraping away	• Dispersion to the surroundings shall be prevented when scraping away contamination. (Example: use of dust collectors, sprinkling in advance, setting up simple plastic housings, etc.)

2) Decontamination for rainwater gutters

The flow of decontamination work for rainwater gutters is shown in Figure 2-12. The necessary measures prior to the decontamination work are shown in Table 2-7. The decontamination methods and notes of caution are shown in Table 2-8.

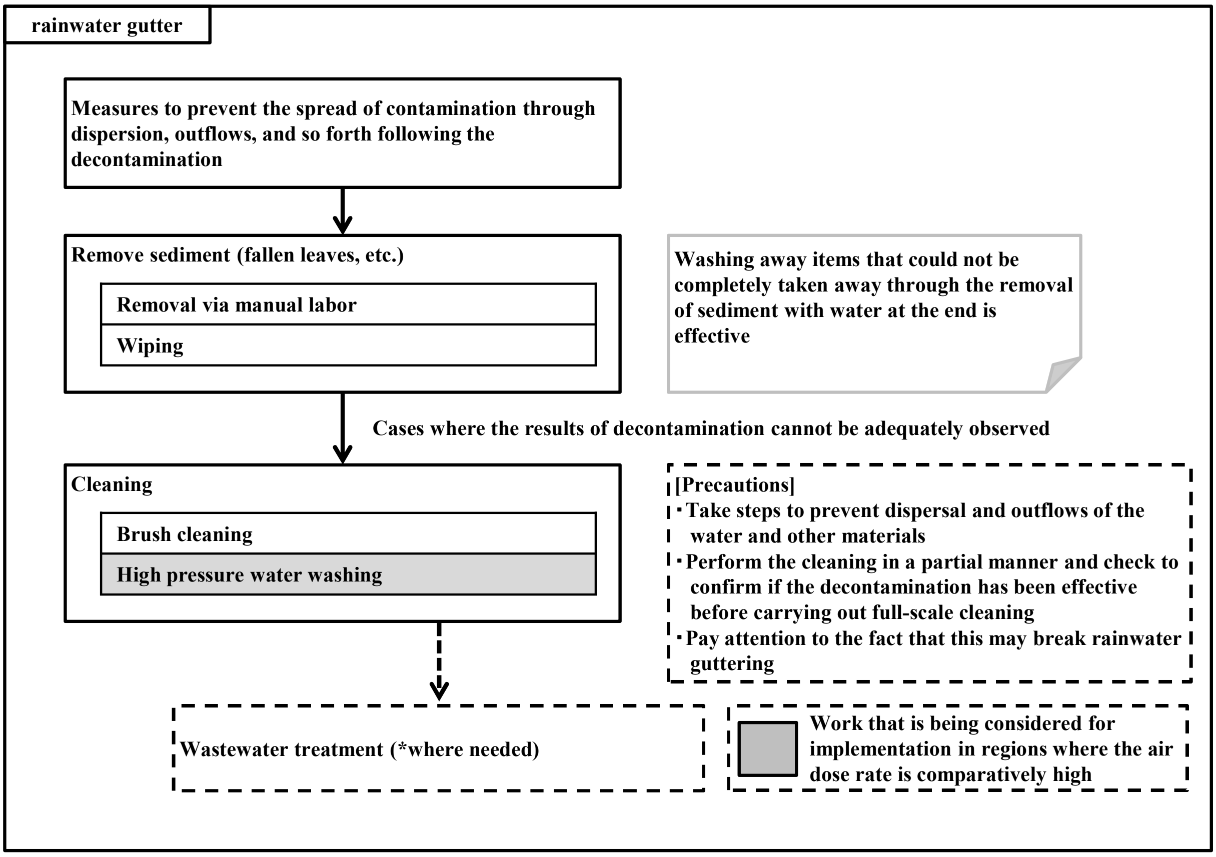


Figure 2-12 Basic flow for the decontamination of rainwater gutters.

Table 2-7 Necessary measures prior to the decontamination of rainwater gutters

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • Sediment in rainwater gutter shall be removed prior to cleaning with water. • See "4. (2) Wastewater Treatment" regarding the treatment of wastewater. • Damage to the end-flow sections of rainwater gutter or places where they are directly discharged into garden plots may result in high doses, so consideration shall be given to the decontamination of gardens and similar sites.

Table 2-8 Decontamination methods for rainwater gutters and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Decontamination through manual labor	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
	Wiping	• Wiping shall be performed carefully through the use of paper towels or dust cloths that have been dampened with water. • All sides of folded paper towels, dust cloths, etc. used in wiping work shall be used. However, none of the surfaces that have already been used for decontamination (wiping) shall be touched with bare hands as these surfaces may have radiocaesium on them. • Consideration shall be given to preventing the contamination from re-adhering by such means as wiping it down with a new side of the cloth for each wipe according to the contamination status. • Since large quantities of radioactive materials accumulate on the sediments in rainwater gutter, it is effective to remove said sediments.
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using scrub brushes, scrubbing brushes, etc. • Sediment in downspouts (especially bend sections) tends to get overlooked, so these should be cleaned with a wire brush. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings.
	High pressure water cleaning	• High pressure water cleaners shall be used to clean via pressure washing with a water pressure of generally 5 MPa or less and around 2 liters of water used per 1 m to ensure that rainwater gutter is not destroyed. This is primarily for narrow places where people cannot reach and other sections where it is difficult to perform wiping work. • ･The spray nozzle shall be brought near to the place being decontaminated (about 20 cm) in order to get results from the cleaning, and the cleaning shall be performed at the appropriate speed of movement. • ･Washing shall be performed from the upstream to the downstream of the drainage slope to ensure that water does not disperse to the surroundings.

3）Decontamination for exterior walls

The flow of decontamination for exterior walls is shown in Figure 2-13. The necessary measures prior to the decontamination work are shown in Table 2-9. The decontamination methods and notes of caution are shown in Table 2-10.

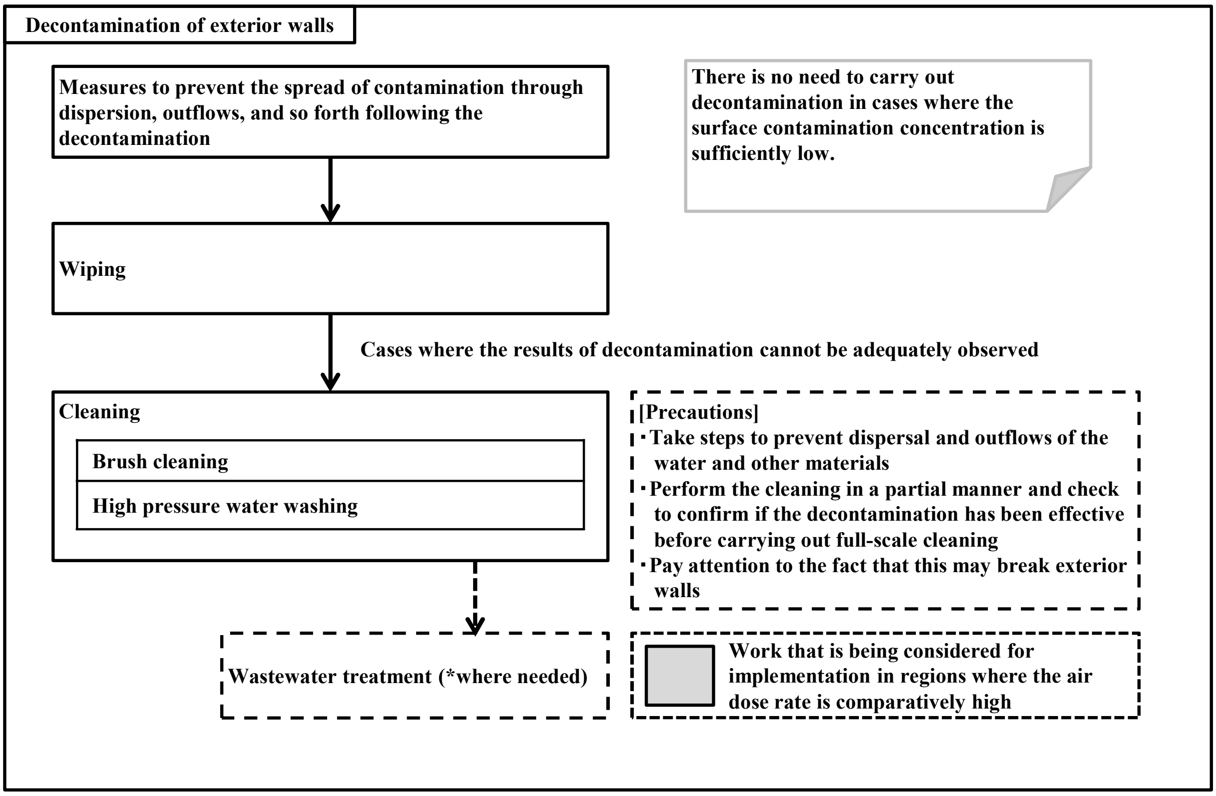


Figure 2-13 Basic flow for the decontamination of exterior walls.

Table 2-9 Necessary measures prior to the decontamination of exterior walls

Category	Decontamination methods and points to notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See "4. (2) Wastewater Treatment" regarding the treatment of wastewater.

Table 2-10 Decontamination methods for exterior walls and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Wiping	• Wiping shall be performed carefully through the use of paper towels or dust cloths that have been dampened with water. • All sides of folded paper towels, dust cloths, etc. used in wiping work shall be used. However, none of the surfaces that have already been used for decontamination (wiping) shall be touched with bare hands as these surfaces may have radiocaesium on them. • Consideration shall be given to preventing the contamination from re-adhering by such means as wiping it down with a new side of the cloth for each wipe according to the contamination status.
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using scrub brushes, scrubbing brushes, etc. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings.
	High pressure water cleaning	• To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • The spray nozzle shall be brought near to the place being decontaminated (about 20 cm) in order to get results from the cleaning, and the cleaning shall be performed at the appropriate speed of movement. • Attention must be paid to the fact that there is the possibility of damaging the property, such as by causing walls to peel, or having water seep indoors.

4) Decontamination for fences, outside walls, benches, and playground equipment, etc.

The flow of decontamination for fences, outside walls, benches, and playground equipment, etc., is shown in Figure 2-14. The necessary measures prior to the decontamination work are shown in Table 2-11. The decontamination methods and notes of caution are shown in Table 2-12.

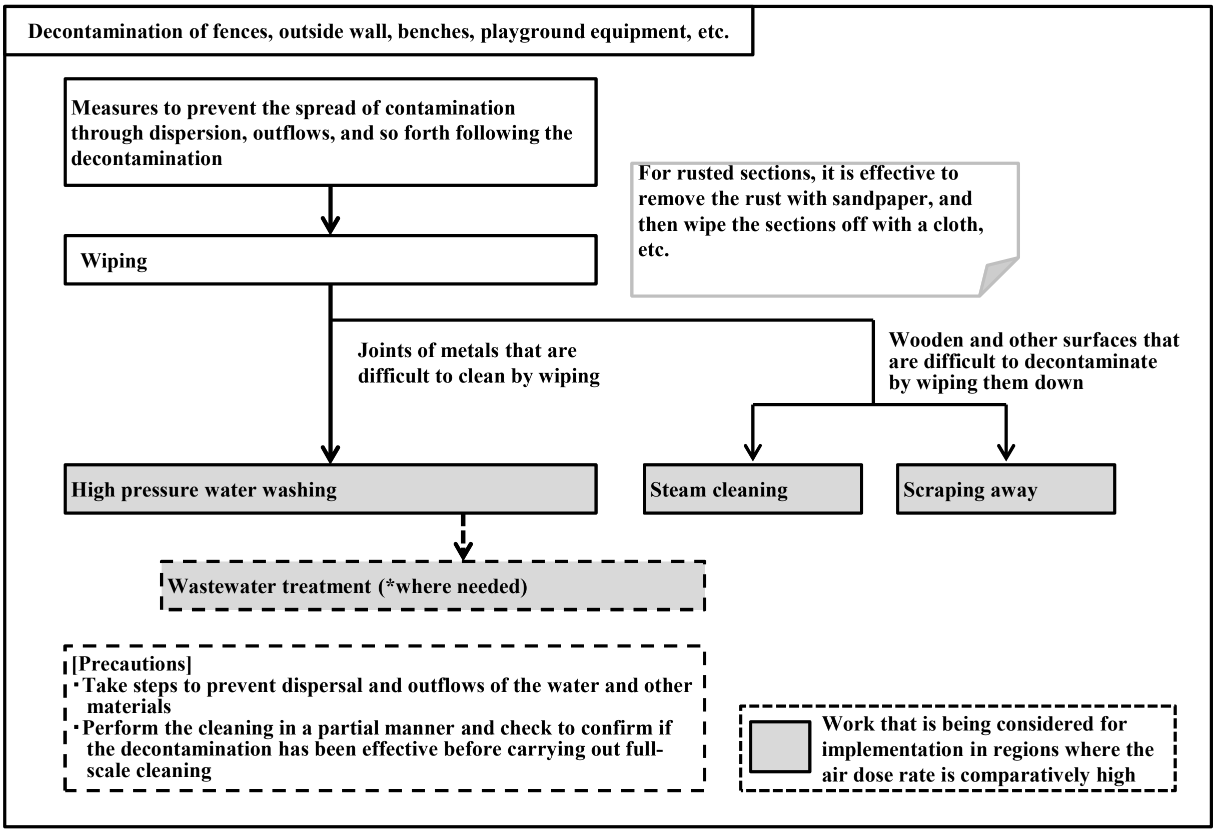


Figure 2-14 Basic flow for the decontamination of fences, outside walls, benches, playground equipment, etc.

Table 2-11 Necessary measures prior to the decontamination of fences, outside walls, benches, playground equipment, etc.

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See "4. (2) Wastewater Treatment" regarding the treatment of wastewater.

Table 2-12 Decontamination methods for fences, outside walls, benches, playground equipment, etc. and notes of caution

Category	Decontamination methods and notes of caution
Wiping	• All sides of folded paper towels, dust cloths, etc. used in wiping work shall be used. However, none of the surfaces that have already been used for decontamination (wiping) shall be touched with bare hands as these surfaces may have radiocaesium on them. • Consideration shall be given to preventing the contamination from re-adhering by such means as wiping it down with a new side of the cloth for each wipe according to the contamination status. • The rust on metal playground equipment shall be removed through the use of sandpaper, a metal brush, or the like before it is thoroughly wiped down. • Once a side of a paper towel or dust cloth has been used on decontamination (wiping) or a brush, waste cloth, or sandpaper has been used for wiping there is the possibility that it will have radiocaesium adhering to it, and so it must not be touched directly by hand.
High pressure water cleaning (metal joints)	• High pressure water cleaning shall be performed on the joints of playground equipment and the like that are difficult to wipe down. • To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • The spray nozzle shall be brought near to the place being decontaminated (about 20 cm) in order to get results from the cleaning, and the cleaning shall be performed at the appropriate speed of movement.
Steam cleaning	• Wooden playground equipment shall be cleaned using a steam cleaner.
Scraping away (wooden playground equipment, etc.)	• The surface wood of wooden playground equipment shall be scraped away with electric power tools or the like. • Dust collectors, etc. shall be used when scraping off wooden surfaces, etc. to prevent dispersion to the surroundings.

5） Decontamination of gardens, etc.

The flow of decontamination for gardens and other similar areas is shown in Figure 2-15. The necessary measures prior to the decontamination work are shown in Table 2-13. The decontamination methods and notes of caution are shown in Table 2-14.

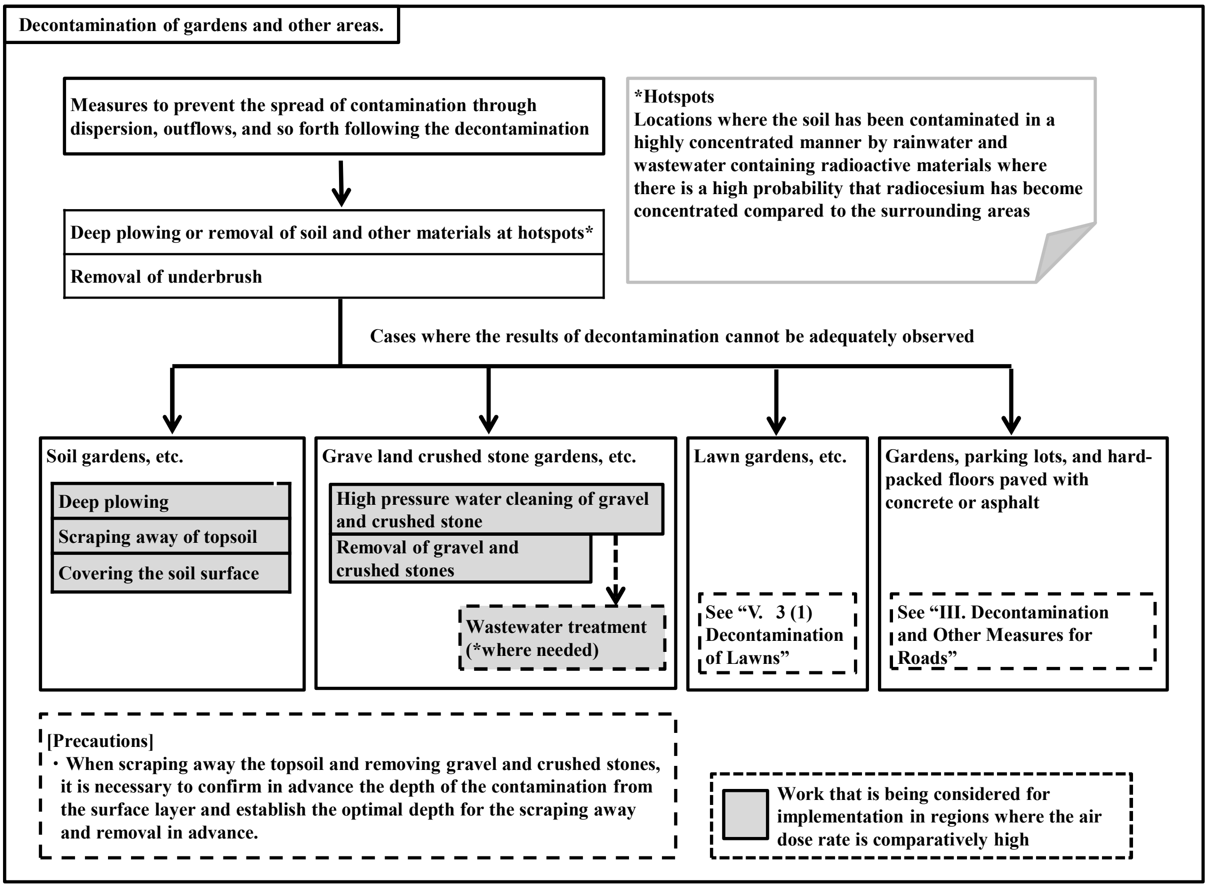


Figure 2-15 Basic flow for the decontamination of gardens and other similar areas.

Table 2-13 Necessary measures prior to the decontamination of gardens and other similar areas

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.

Table 2-14 Decontamination methods for gardens and other similar areas and notes of caution

Category		Decontamination methods and notes of caution
Deep plowing or removal of soil and other substances at hotspots		• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc. • The soil at hotspots below rainwater gutter and the like shall be deep plowed or removed. When this is implemented attention must be paid to the depth of the contamination. • In cases where it is difficult to perform deep plowing at a location, such as with soil that has been packed into rainwater chambers and the like, consideration shall be given to performing deep plowing in the vicinity of said rainwater chambers.
Removal of underbrush, etc.		• Before performing the deep plowing and the scraping away of topsoil, conduct weed removal and weeding on any weeds that would pose a hindrance to the work using a shoulder-type mower or human power. • In some cases the shielding effect for the beta rays by grass may be reduced by the grass cutting, and so the reduction rate may drop.
Gravel and crushed stone gardens, etc.	Deep plowing	• About 10 cm of topsoil shall be uniformly scraped away and temporarily piled on top of a plastic sheet or the like. • About 20 cm of subsoil shall be uniformly scraped away and piled on top of a separate location from the topsoil. • After the topsoil has been uniformly spread out, the subsoil shall be uniformly spread on top of it and the land will be leveled. It shall be restored to its original height at a compactness that is about the same as it was before.
	Scraping away surface soil	• A bamboo winnow or similar instrument shall be used to uniformly scrape away the garden topsoil. • Attention shall be paid to the fact that due to the planted vegetation and unevenness relative to the ground there may be reduced certainty with the decontamination work.
	Covering the surface soil	• The surface soil shall be covered with soil that does not contain radiocaesium.
Gravel and crushed stone gardens, etc.	High pressure water cleaning of gravel and crushed stones	• A shovel or the like shall be used to place the gravel or crushed stones into a water tank and then perform high pressure water cleaning. • To prevent dispersion of soil, etc. by water pressure when performing high pressure water cleaning, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater.
	Removal of gravel and crushed stones	• The gravel or crushed stones shall be uniformly removed with a shovel or the like. • When gravel or crushed stones are removed, the area shall be covered by using the same type of gravel or crushed stones as before as needed, and it shall be covered to the same standing height as before and to about the same compactness as before.

6) Decontamination for street drains, etc.

The flow of decontamination for street drains, etc. is shown in Figure 2-16. The necessary measures prior to the decontamination work are shown in Table 2-15. The decontamination methods and notes of caution are shown in Table 2-16.

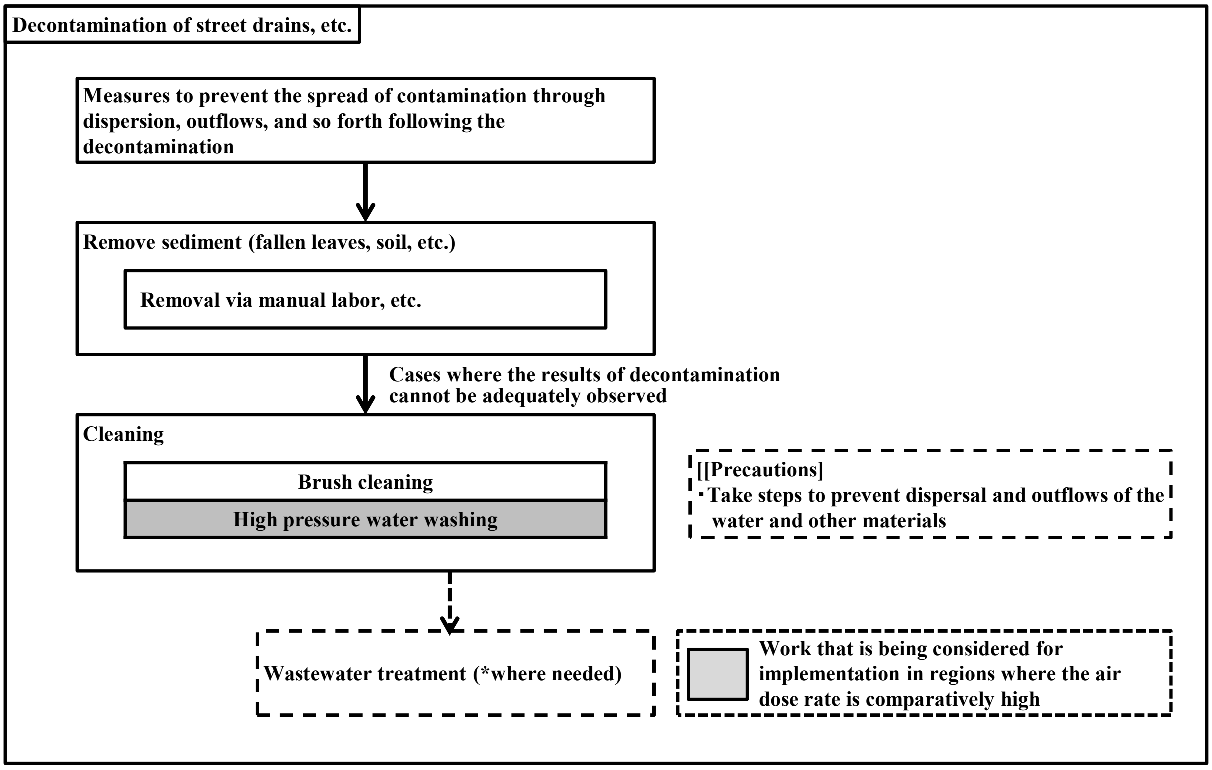


Figure 2-16 Basic flow for the decontamination of street drains, etc.

Table 2-15 Necessary measures prior to the decontamination of street drains, etc.

Category	Decontamination methods and points to notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See "4. (2) Wastewater Treatment" regarding the treatment of wastewater.

Table 2-16 Decontamination methods for street drains, etc. and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Decontamination through manual labor	• Fallen leaves, moss, mud, and other sediments that are easy to remove shall be removed in advance by shovel, etc. • When the concrete joints of street drains are deep, a spatula or the like shall be used to remove the sediments from the joints. • When performing deep plowing at rainwater chambers it will be difficult to carry this out in such locations, and so deep plowing shall be carried out in the vicinity of said rainwater chambers. • In cases where sediment gets clogged in rainwater chambers and water overflows out of street drains like when it rains contamination will sometimes spread to the surroundings. In such cases the ground surface of the surroundings shall be measured and decontamination work shall be carried out in accordance with the configuration of the ground surface.
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using a deck brush or broom. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings.
	High pressure water cleaning	• To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • The spray nozzle shall be brought near to the place being decontaminated (about 20 cm) in order to get results from the cleaning, and the cleaning shall be performed at the appropriate speed of movement.

(4) Post–work measures

This section explains handling the removed soil, etc., wastewater treatment, and cleaning equipment used, etc. as post-work measures.

1) Handling the removed soil, etc.

The removed soil, etc. is appropriately handled and transferred to an on-site storage or a temporary storage site. The basic flow of handling the removed soil, etc. is shown in Figure 2-17. The methods of handling and notes of caution are explained in Table 2-17.

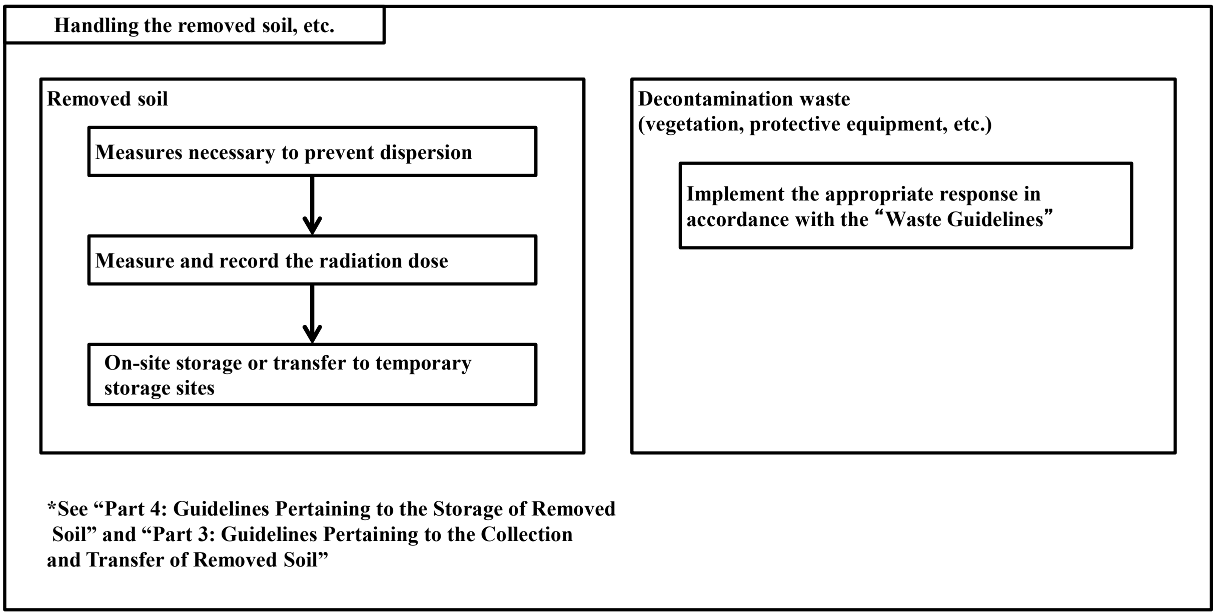


Figure 2-17 Basic flow for handling the removed soil, etc.

Table 2-17 Methods for the handling of removed soil, etc. and notes of caution

Category	Decontamination methods and notes of caution
Handling the removed soil, etc.	• To prevent dispersion, the removed soil, etc. shall be placed in bags or other containers and closed or sealed, or wrapped in sheets or similar material. • The removed soil, etc. shall be separated from decontamination waste to the extent possible and placed in separate bags or other containers to ensure there is no mixing. Please refer to the Guidelines on the Storage of Decontamination Waste (promulgated at the end of December 2011) for details on the handling of waste. • The air dose rate at the surface (from 1 cm away) of each container or set of multiple containers holding the removed soil, etc. shall be measured, and the radiation dose of the removed soil, etc. generated by the decontamination work shall be recorded and displayed in a manner that roughly indicates the dose level (range). • Vegetation and the disposable masks, etc. used in the decontamination work shall be treated and disposed of as decontamination waste in accordance with the Waste Guidelines (March 2013, Vol.2) and other relevant statutes.

2）Wastewater treatment

In cases where wastewater is generated as a result of decontamination, wastewater treatment should be carried out as needed. The flow of wastewater treatment is shown in Figure 2-18. The necessary measures prior to the wastewater treatment are shown in Table 2-18. The methods for treatment and notes of caution are shown in Table 2-19.

For decontamination in decontamination zones (zones subject to the decontamination plans established by municipalities) there is essentially no need to treat wastewater in cases where sediments are removed. However, it is a basic principle that wastewater treatment should be carried out in situations where the wastewater is highly turbid or the wastewater has been recovered from water recovery-type high pressure water washing.

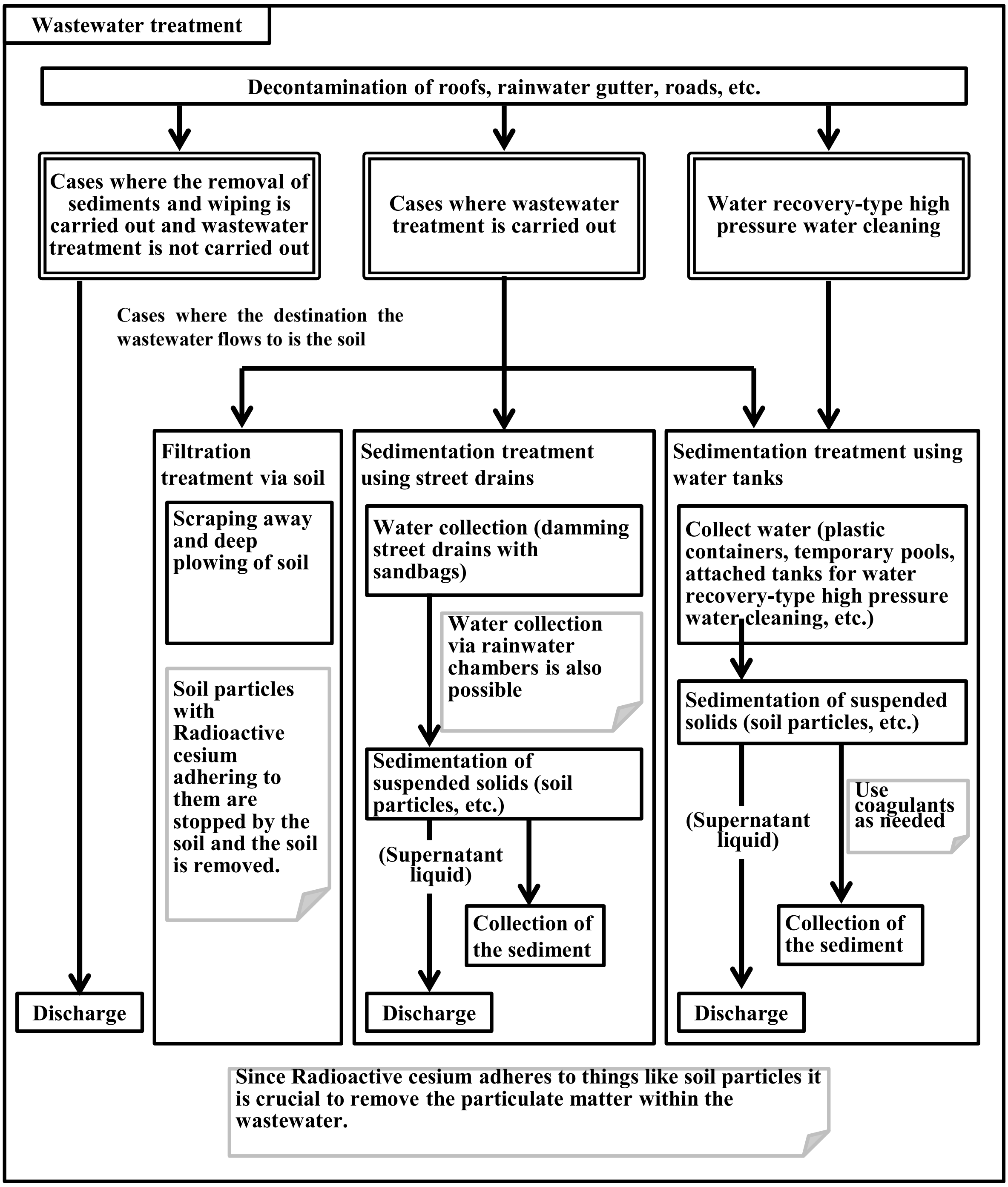


Figure 2-18 Basic flow for wastewater treatment.

Table 2-18 Necessary measures prior to the wastewater treatment

Category	Decontamination methods and notes of caution
Ensuring drainage channels and wastewater treatment	• The channel down which the wastewater will flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage.

Table 2-19 Methods for wastewater treatment and notes of caution

Category	Decontamination methods and notes of caution
Filtration treatment via soil	• When the area under rainwater gutter consists of soil, radiation shall be captured by flushing wastewater generated on rooftops down to the soil via the rainwater gutter, and then said top layer of soil shall be removed after the decontamination of the rooftop.
Sedimentation treatment using water tanks	• Water shall be collected in plastic containers or temporary pools, then sedimenting out the particulate matter, and discharging the water from the supernatant liquid while collecting the sediment (agents to cause the liquid to undergo coagulating sedimentation shall be used). • The water in the supernatant liquid shall be checked to make sure there is no turbidity. • A simple filter will be installed and filtration shall be carried out as needed.
Sedimentation treatment using street drains	• The water shall be collected by damming up the street drains using sandbags, then sedimenting out the particulate matter, and discharging the supernatant liquid while collecting the sediment. • The water in the supernatant liquid shall be checked to make sure there is no turbidity. • A simple filter will be installed and filtration shall be carried out as needed.

3) Cleaning equipment used, etc.

With regard to the post-work cleaning of the equipment used and handling consumable materials for decontamination, as a general rule, the Ministry of Health, Labour and Welfare's "Ordinance on the Prevention of Ionizing Radiation Hazards Related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulting from the Great East Japan Earthquake" and "Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Works" are to be followed. Moreover, it is important to keep in mind the items listed in Table 2-20.

Table 2-20 Methods for cleaning equipment and handling materials and notes of caution

Category	Details
Cleaning equipment and materials	• Heavy machinery, vehicles, and other objects used for which there is the possibility that a great deal of contaminated soil is adhering to them shall be checked to confirm the extent to which said soil is adhering to them. Those objects to which a great deal of contaminated soil is adhering shall be cleaned in a designated location, and other measures shall be taken to ensure that the contaminated soil, etc. is not spread around indiscriminately. • Likewise for shovels and other tools, shoes, and work clothes to which lots of contaminated soil is adhering, these shall be checked to confirm the extent to which said soil is adhering to them. Those objects to which a great deal of contaminated soil is adhering shall be cleaned in a designated location, and other measures shall be taken to ensure that the contaminated soil, etc. is not spread around indiscriminately. • The wastewater generated by the cleaning shall be treated as needed by referring to "(2) Wastewater Treatment." • When cleaning, the workers shall take care to ensure that they are not bathed in the spray from this. • In addition, even equipment or materials with a low possibility of contamination shall be checked to confirm whether or not contaminated soil is adhering to them. • The equipment, materials, and work clothes used shall be washed, cleaned, and reused to the extent possible. [Washing/cleaning examples] • Steam cleaning is effective for cleaning machinery, but scrubbing it down with brushes and a detergent is also sufficient. • Normal methods are sufficient for washing work clothes and other clothing. • When carrying the clothing, etc. used in decontamination work, it shall be placed in a box or bag, etc. to minimize dispersal of the attached matter. • When going indoors after decontamination work, mud shall be removed from shoes, clothing shall be changed, and other measures shall be taken to avoid bringing indoors dust attached to the workers.

(5) Subsequent measurements and records

To confirm the decontamination effect, the air dose rate, etc. after completion of the decontamination work should be measured and recorded as shown in Table 2-21.

Table 2-21 Subsequent measurements and records for the decontamination of buildings and other structures

Measurement of air dose rate, etc.	• The air dose rate, etc. shall be measured at each measurement point. • Measurements shall be carried out in the same location as the prior measurements and under the same conditions to the extent possible. • For the measuring apparatus, the same apparatus as was used for the prior measurements shall be used to the extent possible.
Recordkeeping	• The air dose rate, etc. at each measurement point, places where decontamination work was performed, decontamination date, names of the decontaminators, type of objects decontaminated, decontamination methods, total decontamination area (of soil, etc.), the approximate weight of the removed soil, etc., and the status of storage and disposal. • The equipment used in decontamination and the method of disposal after use. • See "Part 4: Guidelines Pertaining to the Storage of Removed Soil" for details on the items to record with regard to the storage of removed soil.

2.2.3. Decontamination and Other Measures for Roads

This section explains preparation, prior measurements, decontamination methods, post-work measures, and subsequent measurements and records, in the basic flow shown in Figure 2-19, pertaining to measures for decontamination of the paved surfaces of roads (including sidewalks), street drains, curbs, guardrails, and pedestrian overpasses.

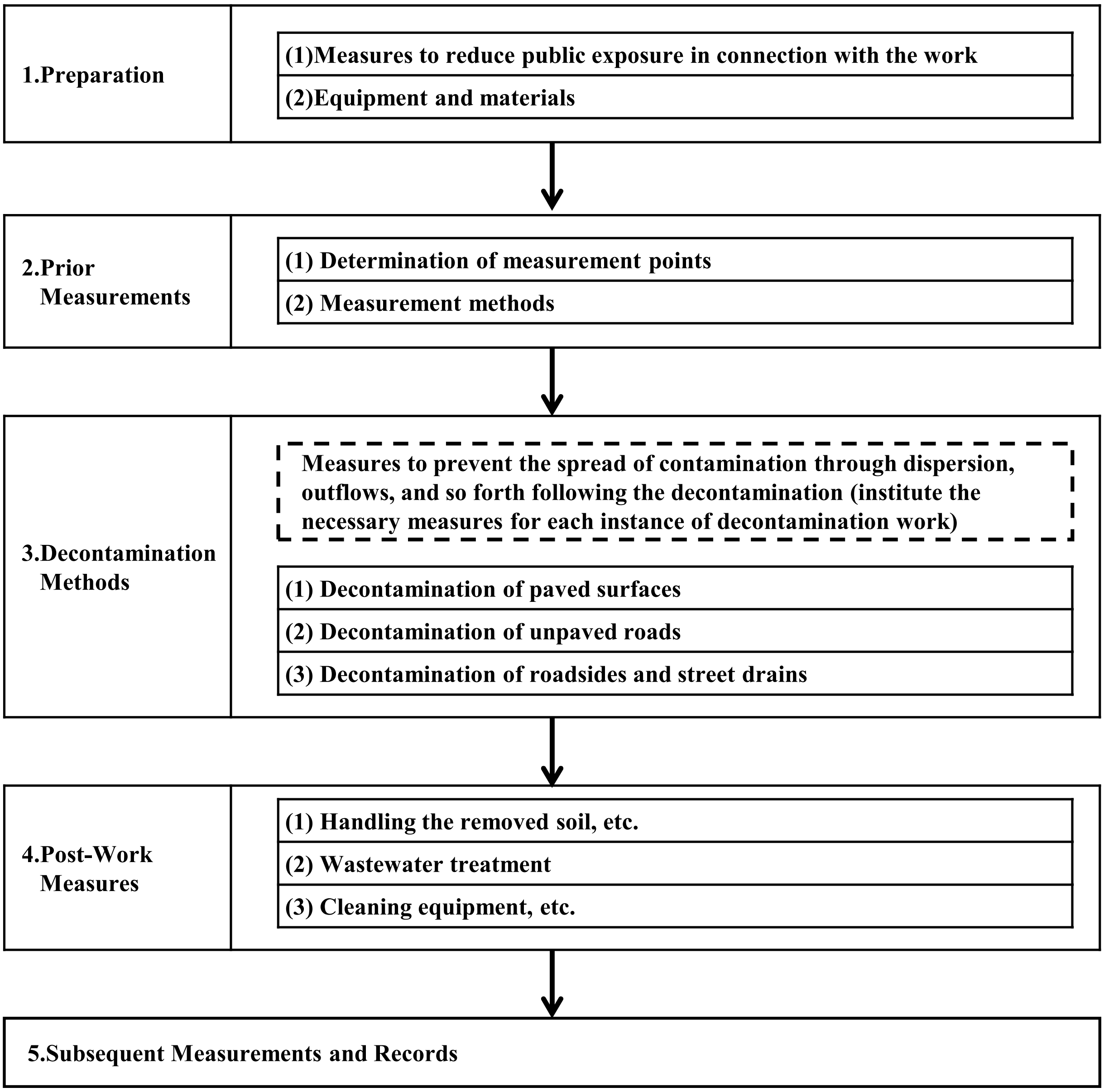


Figure 2-19 Basic flow for the decontamination and other measures for roads.

（1） Preparation

Before performing decontamination work, in addition to preparing the equipment required for the work, preparations must be made to ensure safety of workers and the general public to prevent their exposure to hazards, such as by inhaling dust generated during decontamination work; these preparations are summarized in Table 2-22.

Table 2-22 Preparation for decontamination and other measures for roads

Measures to Reduce Public Exposure in Connection with Decontamination Work	Restriction of entry	• In cases where the general public is deemed likely to enter the area, the area shall be cordoned off with pylons or rope, etc. to prevent people from unnecessarily approaching the work site, and the entry of people and vehicles shall be restricted. • In cases where radioactive materials may be dispersed in connection with the decontamination work, the perimeter of the decontamination area shall be fenced in with sheets, etc., water shall be sprayed, or other such measures shall be taken to prevent dispersion and the area shall be cordoned off with rope, etc.
	Signage	• In cases where the general public is deemed likely to enter the area, signs, etc. shall be put up to alert the public that decontamination work is being performed general
Preparation of Equipment and Materials	General equipment	Examples: Mower, hand shovel, grass sickle, broom, bamboo-rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags)), vehicles for transporting collected removed soil, etc. to the on-site storage location (truck, two-wheeled cart, wheelbarrow, etc.), aerial vehicle, ladder, road sweeper
	Equipment for cleaning with water	Examples: Hose for water discharge, high pressure water cleaner, drainage pavement functional recovery car, brushes (scrub brush, brush for cleaning vehicles, etc.), tools for pushing away water (broom, scraper, etc.), bucket, detergent, dustcloth, sponge, paper towels
	Equipment for scraping off	Examples: Shot blaster, surface cutter, vibration drill, needle gun, grinding machine, equipment for scraping away, ultra high pressure water cleaner, equipment needed to prevent dispersion(dust collector, curing material)
	Equipment for removal of topsoil	Examples: Backhoe, bulldozer, hydraulic shovel
	Equipment for covering the soil surface	Examples: Self-propelled surface compaction roller, plywood for surface compaction, sprinkling equipment

（2） Prior measurements

The air dose rate, etc. should be measured and recorded at the same location and by the same method both before and after decontamination work in order to confirm decontamination effects. The method of measurement for the air dose rate, etc. before decontamination work is explained below.

1) Determination of measurement points

Before decontamination work, the measurement points (Table 2-23) at which the air dose rate, etc. are to be measured should be decided and a schematic diagram illustrating the range of the measured objects, the measurement points, structures to be used as markers, etc. should be made (Figure 2-20). In addition, in setting these measurement points, hotspots and their ambient areas that contribute insubstantially to the radiation dose in the living space are not to be used as measurement points unless the users, etc. are deemed likely to spend relatively large amounts of time there.

Table 2-23 Reasoning behind the measurement points for air dose rates and and other measures and the decontamination of roads

Measurement points	No. 1 measurement points (①)	No. 2 measurement points(②)
Objects subject to measurement	Air dose rate in living spaces	Surface contamination density, etc. for objects subject to decontamination
Reasoning behind the measurement points	• Measurement points shall be set at intervals that allow the air dose rate distribution to be ascertained near the centerline of sidewalks. • If there are no sidewalks, appropriate points shall be determined by confirming the usage status of the road. (Example)Pitch of approx. 10 –30 m	• Measurement points shall be set at intervals that allow the air dose rate, etc. distribution to be ascertained for each road surface, road shoulder, street drain, and sidewalk. (Example)Pitch of approx. 10 –30 m

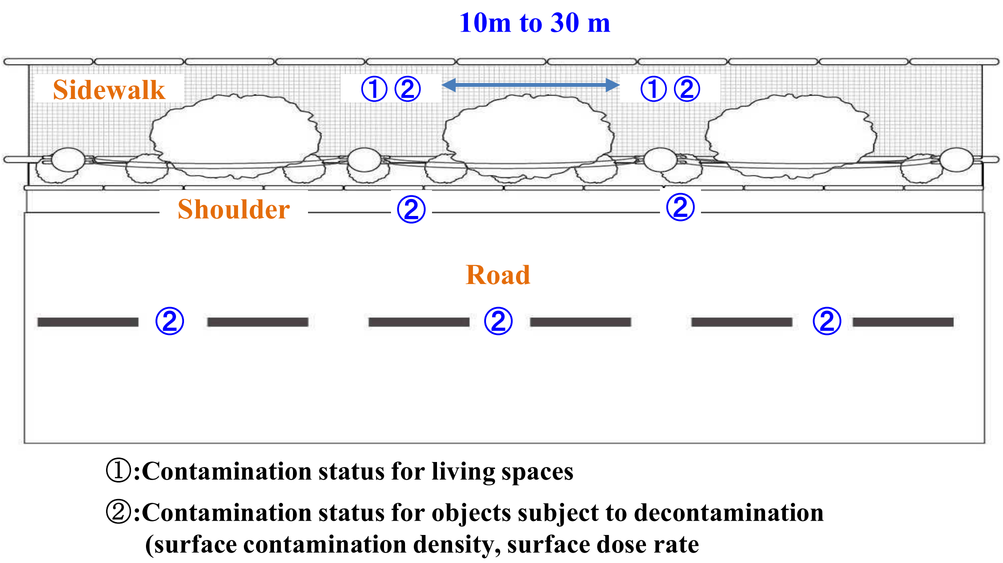


Figure 2-20 Example schematic diagram for reporting measurement points for use in decontamination and other measures for roads.

2) Measurement methods

It is recommended that for the measurement point marked as ① the apparatuses such as NaI scintillation survey meters which are able to measure gamma rays should be used and for the measurement point marked as ②, GM survey meters should be used.

(3) Decontamination methods

This section explains the flow of the overall decontamination work for roads (Figure 2-21) that is efficiently focused on the places with comparatively high concentrations of radioactive materials that contribute substantially to the radiation dose. When water is used in decontamination work on roads or for similar work, radioactive materials may migrate to the roadsides or street drains. Therefore, when using water, it is more efficient to first remove the sediments from the roadsides and street drains, then clean the roads, and finally clean the roadsides and street drains again. Decontamination methods for roadsides and street drains, as well as paved surfaces and unpaved roads are described in terms of the items such as basic flow, necessary measures for prior decontamination work and decontamination methods and notes of caution.

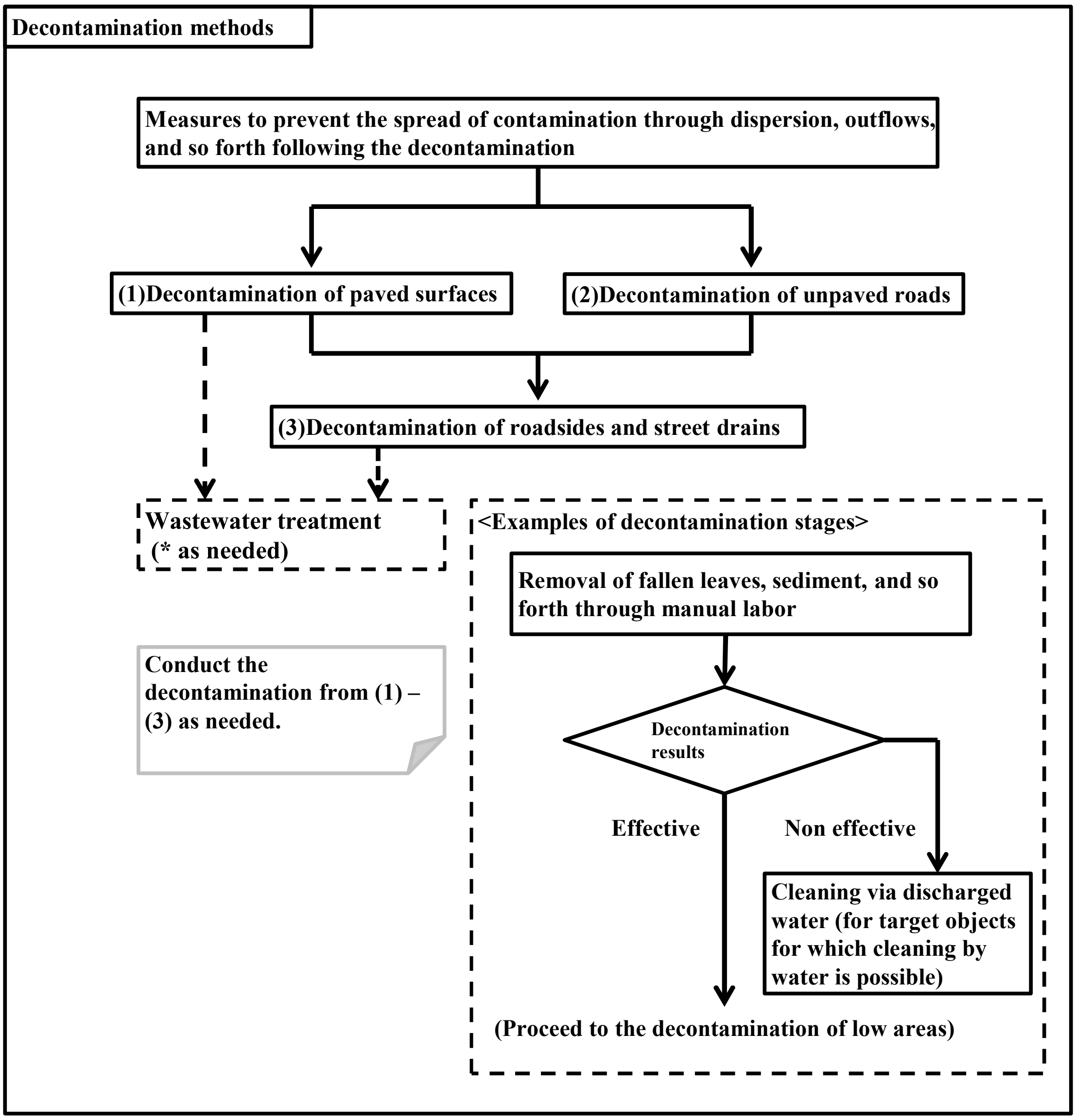


Figure 2-21 Basic flow for the decontamination of roads.

1）Decontamination of paved surfaces

This section explains the flow of decontamination for paved surfaces of roads (and sidewalks) as shown in Figure 2-22. The necessary measures prior to the decontamination work are in Table 2-24. The decontamination methods and notes of caution are in Table 2-25.

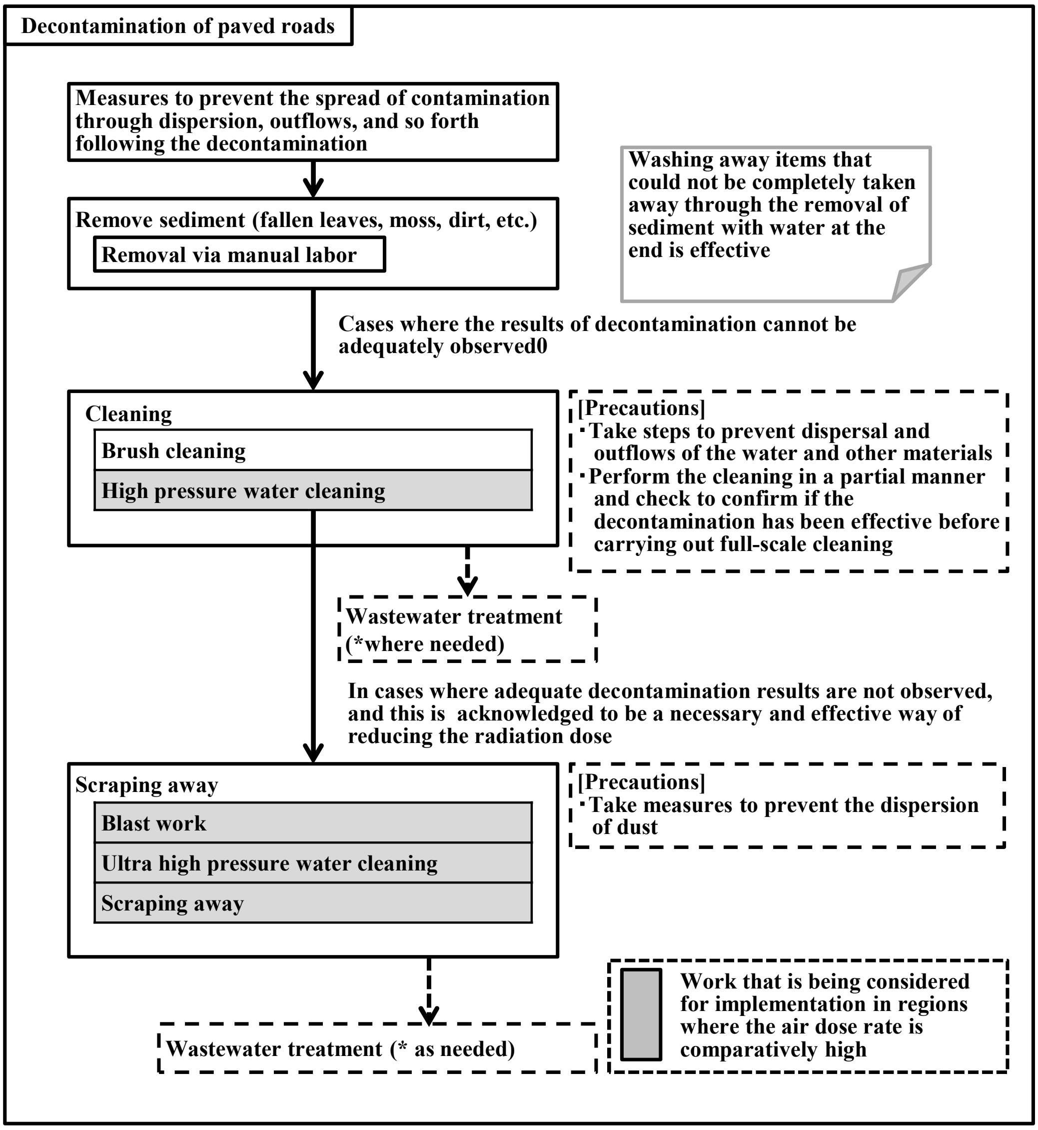


Figure 2-22 Basic flow for the decontamination of paved surfaces.

Table 2-24 Necessary measures prior to the decontamination of paved surfaces

Category	Decontamination methods and notes of caution
Safety management	• If traffic cannot be stopped when the decontamination work is carried out, then adequate safety management shall be undertaken through measures like allocating traffic controllers or the like.
Prevention of dispersion	• When carrying out decontamination work that uses water, measures shall be taken to prevent the dispersion of the cleaning water.
Ensuring drainage channels and wastewater treatment	• Sediment on roads, on roadsides, and in street drains shall be removed before cleaning with water. • When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater.

Table 2-25 Decontamination methods for paved surfaces and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Removal through manual labor	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves, shovel, or road sweeper, etc.
Cleaning	Brush cleaning	• Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings. • With drainage pavement functional recovery cars, attention must be paid to the fact that in some cases their cleaning and drainage recovery functions may decline on surfaces where distortion or wear has occurred due to the effects of earthquakes, etc.
	High pressure water cleaning	• To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • Water recovery-type high pressure water cleaning is also effective. • To achieve a decontamination effect, the spray nozzle shall be brought near the place to be decontaminated. • When decontamination is carried out over a wide range, attention must be paid to ensure that no variance occurs between the work methods at different points (height of the nozzle over the ground, work time per unit of surface area, etc.)
Scraping away	Blast work	• Abrasive materials shall be shot at the surface with a shot blaster and scraped away from said surface uniformly. • In order to prevent dust from arising, curing, etc. shall be performed to prevent dispersion of dust to the surroundings and the dust shall be collected. • For blast work, curing shall be performed to ensure that abrasive materials and the like do not travel outside of the decontamination work zone. What is more, after the abrasive materials and other materials have been used they shall be collected in a manner that ensures that they will not scatter the radioactive materials adhering to them to the surroundings. • When scraping away material on interlocking concrete blocks, attention must be paid to the fact that scrapings and radioactive materials may be left behind in the gaps between the blocks.
	Ultra-high pressure water cleaning	• Ultra-high pressure water cleaner (cleaning water recovery-type) of 150 MPa or higher shall be used for scraping material away on paved surfaces. • A powerful vacuum truck shall be used to collect any scrapings that arise.
	Scraping away	• A surface cutter or the like shall be used to scrape away the paved surface. • Dispersion to the surroundings shall be prevented when scraping away contamination. • (Example: use of dust collectors, sprinkling in advance, setting up simple plastic housings, etc.)

2）Decontamination of unpaved roads

The flow of decontamination for unpaved surfaces of roads is shown in Figure 2-23. The necessary measures prior to the decontamination work are in Table 2-26. The decontamination methods and notes of caution are in Table 2-27.

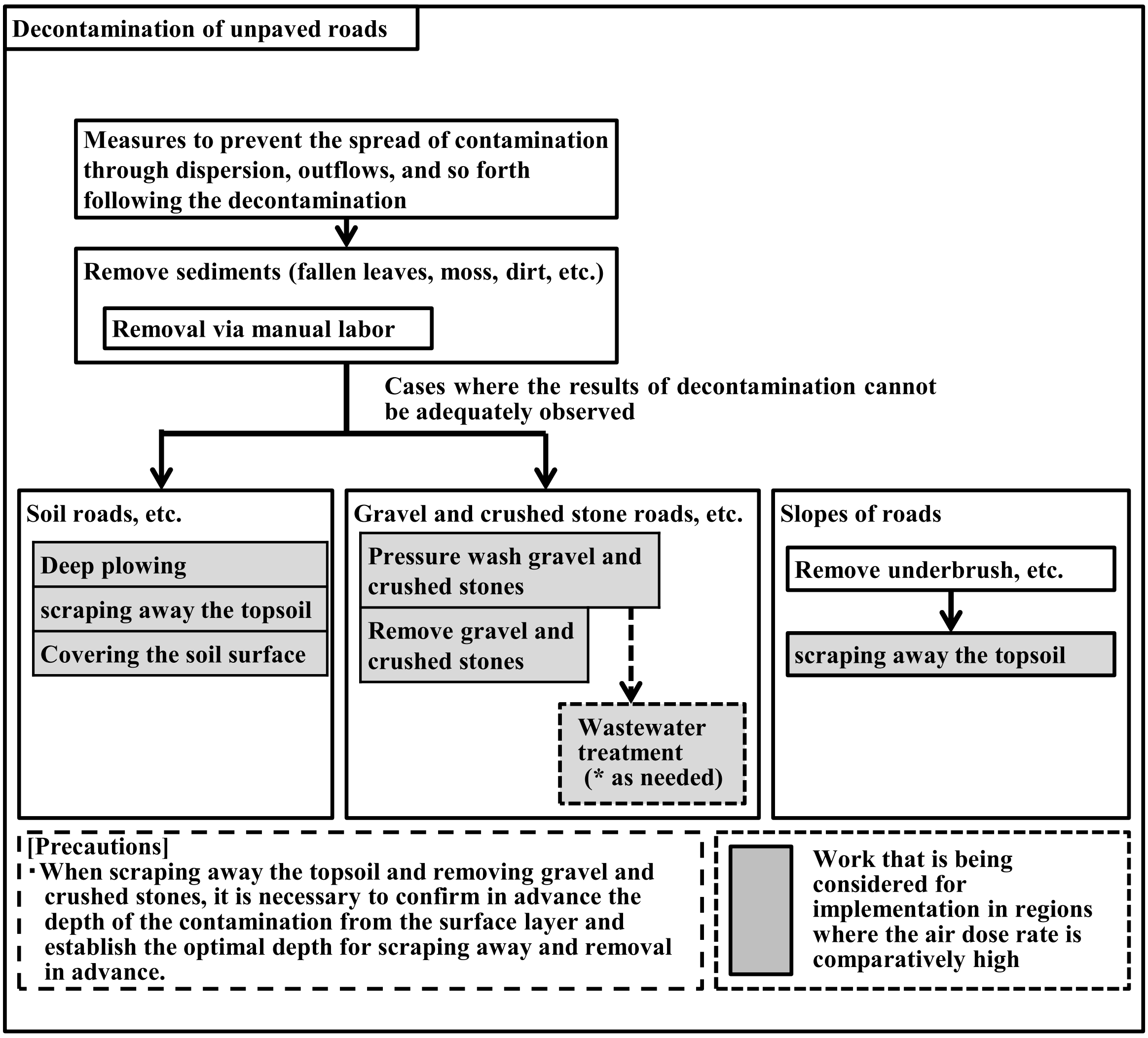


Figure 2-23 Basic flow for the decontamination of unpaved roads.

Table 2-26 Necessary measures prior to the decontamination of unpaved roads

Category	Decontamination methods and notes of caution
Prevention of dispersion	• When scraping away the topsoil when it comes to dried soil, efforts can be made to prevent the dispersion of dust by scattering solidification agents over the area in advance to solidify the soil surface.

Table 2-27 Decontamination methods for unpaved roads and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Removal through manual labor	• Soil with fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
Soil roads, etc.	Deep plowing	• About 10 cm of topsoil shall be uniformly scraped away and temporarily piled on top of a plastic sheet or the like. • About 20 cm of subsoil shall be uniformly scraped away and piled on top of a separate location from the topsoil. • After the topsoil has been uniformly spread out, the subsoil shall be uniformly spread on top of it and the land will be leveled. It shall be restored to its original height at a compactness that is about the same as it was before.
	Scraping away topsoil	• A backhoe or the like shall be used to uniformly scrape away the surface. • Dispersion to the surroundings shall be prevented when scraping away contamination. (Example: use of dust collectors, sprinkling in advance, setting up simple plastic housings, etc.)
	Covering the surface soil	• The surface soil shall be covered with soil that does not contain radiocaesium.
Gravel and crushed stone roads, etc.	High pressure water cleaning of gravel and crushed stones	• A backhoe or the like shall be used to place the gravel or crushed stones into a water tank and then high pressure water cleaning will be performed. • To prevent dispersion of soil, etc. by water pressure when performing high pressure water cleaning, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • See "4. (2) Wastewater Treatment" regarding the treatment of wastewater.
	Removal of gravel and crushed stones	• The gravel or crushed stones shall be uniformly removed with a backhoe or the like. • When gravel or crushed stones are removed, the area shall be covered by using the same type of gravel or crushed stones as before, and it shall be covered to the same standing height as before and to about the same compactness as before. • Attention shall be paid to the fact that because of the large air gaps when covering with crushed stones, density adjustments shall be performed via the appropriate surface compaction.
Slopes of roads	Removal of underbrush	• Weed removal and weeding shall be conducted using a shoulder-type mower or human power.
	Removal of topsoil	• Human power, a backhoe, or the like shall be used to uniformly scrape away the surface. • Dispersion to the surroundings shall be prevented when scraping away contamination.

3）Decontamination of roadsides and street drains

The flow of decontamination for roadsides and street drains is shown in Figure 2-24. The necessary measures prior to the decontamination work are in Table 2-28. The decontamination methods and notes of caution are in Table 2-29.

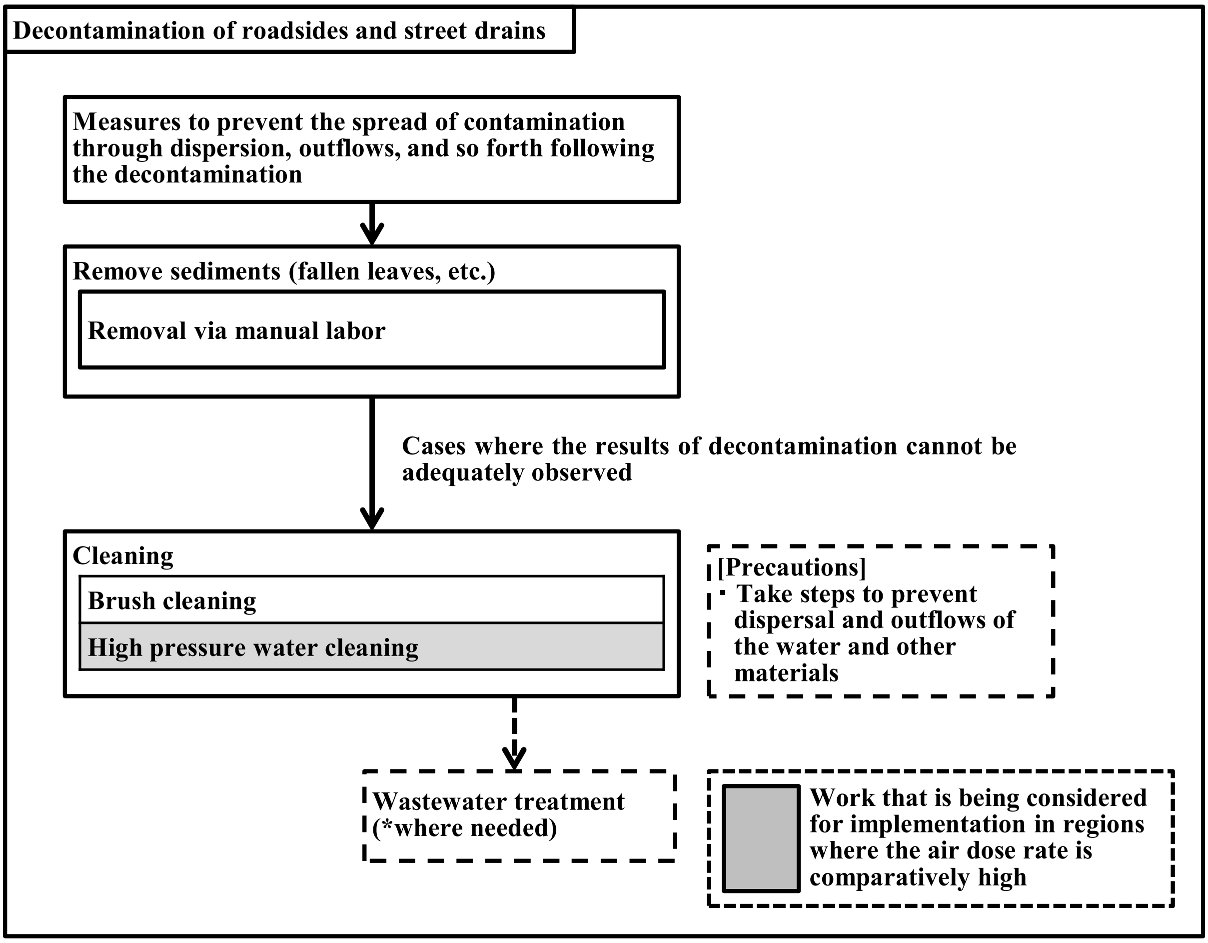


Figure 2-24 Basic flow for the decontamination of roadsides and street drains.

Table 2-28 Necessary measures prior to the decontamination of roadsides and street drains

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See "4. (2) Wastewater Treatment" regarding the treatment of wastewater.

Table 2-29 Decontamination methods for roadsides and street drains and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Removal through manual labor	• Fallen leaves, moss, mud, and other sediments that are easy to remove shall be removed in advance by shovel, etc. • When the concrete joints of street drains are deep, a spatula or the like
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using scrub brushes or scrubbing brushes. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings.
	High pressure water cleaning	• To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • To achieve a decontamination effect, the spray nozzle shall be brought near the place to be decontaminated.

(4) Post–work measures

This section explains handling the removed soil, etc., wastewater treatment, and cleaning equipment used, etc. as post-work measures.The details appear in 2.2.2.(4) of this report.

(5) Subsequent measurements and records

To confirm the decontamination effect, the air dose rate, etc. should be measured after completion of the decontamination work and recorded as shown in Table 2-30.

Table 2-30 Subsequent measurements and records for the decontamination of roads

Measurement of air dose rate, etc.	• The air dose rate, etc. shall be measured at each measurement point. • Measurements shall be carried out in the same location as the prior measurements and under the same conditions to the extent possible. • For the measuring apparatus, the same apparatus as was used for the prior measurements shall be used to the extent possible.
Recordkeeping	• The air dose rate, etc. at each measurement point, places where decontamination work was performed, decontamination date, names of the decontaminators, type of objects decontaminated, decontamination methods, total decontamination area (of soil, etc.), the approximate weight of the removed soil, etc., and the status of storage and disposal. • The equipment used in decontamination and the method of disposal after use. • See "Part 4: Guidelines Pertaining to the Storage of Removed Soil" for details on the items to record with regard to the storage of removed soil.

2.2.4. Decontamination and Other Measures for Soil

This section explains preparation, prior measurements, decontamination methods, post-work measures, and subsequent measurements and records, in the basic flow (Figure 2-25), pertaining to decontamination and other measures for soil in schoolyards, kindergarten yards, parks, farmland, and other comparatively large land spaces.

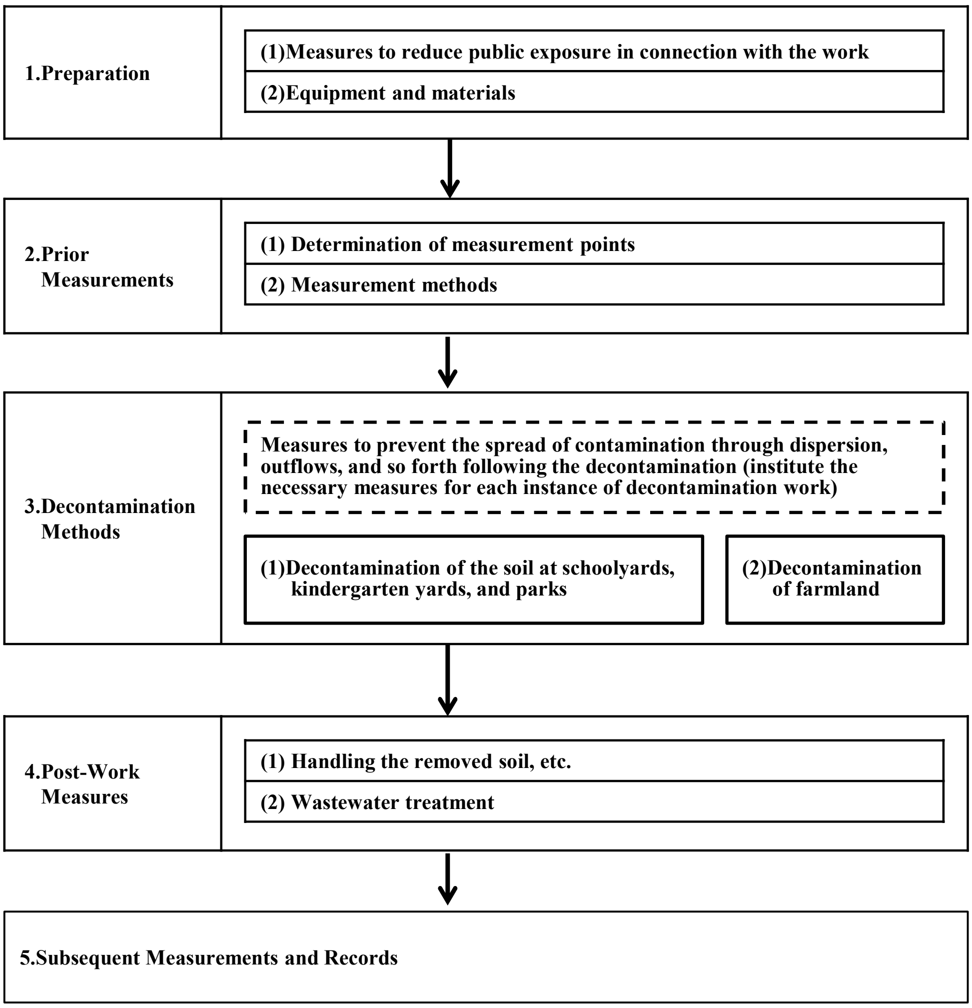


Figure 2-25 Basic flow for decontamination and other measures for soil.

(1) Preparation

Before performing decontamination work, in addition to preparing the equipment required for the work, preparations must be made to ensure safety of workers and the general public to prevent their exposure to hazards, such as by inhaling dust generated during decontamination work; these preparations are summarized in Table 2-31.

Table 2-31 Preparation for decontamination and other measures for soil

Measures to Reduce Public Exposure in Connection with Decontamination Work	Restriction of entry	• In cases where the general public is deemed likely to enter the area, the area shall be cordoned off with pylons or rope, etc. to prevent people from unnecessarily approaching the work site, and the entry of people and vehicles shall be restricted. • In cases where radioactive materials may be dispersed in connection with the decontamination work, the perimeter of the decontamination area shall be fenced in with sheets, etc., water shall be sprayed, or other such measures shall be taken to prevent dispersion and the area shall be cordoned off with rope, etc.
	Signage	• In cases where the general public is deemed likely to enter the area, signs, etc. shall be put up to alert the public that decontamination work is being performed.
Preparation of decontamination equipment and materials	General equipment	Examples: Mower, hand shovel, grass sickle, broom, bamboo rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags), large sandbags, flexible containers), vehicles for transporting collected removed soil, etc. to the on-site storage location or temporary storage site(truck, two-wheeled cart, etc.), aerial vehicle, ladder
	Equipment for cleaning with water	Examples: Hose for water discharge
	equipment for removal of topsoil	Examples: Bulldozer, hydraulic shovel
	Equipment for covering soil surfaces	Examples: Self-propelled surface compaction roller, plywood for surface compaction, sprinkling equipment
	Decontamination equipment for use on farmland: Equipment for scraping away topsoil	Examples: Equipment required for scraping away topsoil, inversion tillage, and deep tillage (bulldozer, hydraulic shovel, tractor, vertical harrow and other attachments, rear blade, front loader), backhoe, grader, crane, vacuum car, mower, high pressure water cleaner, chipping machine, hammer knife mower, flexible containers
	Decontamination equipment for use on farmland: Equipment for mixing with water	Examples : Tractor, vertical harrow and other attachments, drainage pump, backhoe, crane, mower, water shielding sheets, flexible containers
	Decontamination equipment for use on farmland: Equipment for inversion tillage and deep tillage	Examples: Tractor, deep-tillage plow, deep-tillage rotary, mower

(2) Prior measurements

The air dose rate, etc. should be measured and recorded at the same location and by the same method both before and after decontamination work in order to confirm decontamination effects. The method of measurement for the air dose rate, etc. before decontamination work is explained below.

1) Determination of measurement points

Before decontamination work, the measurement points (Table 2-32) at which the air dose rate, etc. are to be measured should be decided and a schematic diagram illustrating the range of the measured objects, the measurement points, structures to be used as markers, etc. should be made (Figure 2-26). In addition, in setting these measurement points, hotspots and their ambient areas that contribute insubstantially to the radiation dose in the living space should not be used as measurement points unless the users, etc. are deemed likely to spend relatively large amounts of time there..

Table 2-32 Reasoning behind the measurement points for air dose rates and other measures for the decontamination of soil

Measurement point	No. 1 measurement points(①)	No. 2 measurement points (②)
Measurement target	Air dose rate in living spaces	Surface contamination density, etc. for objects subject to decontamination
Reasoning behind the measurement points	• ･Measurement points shall be set at intervals that allow the air dose rate distribution to be ascertained. 【Schools (school buildings, schoolyards)】 • For schoolyards, the schoolyards shall be divided up into meshes of about 10 –30 m and measurements shall be conducted at one spot in each mesh (in cases where there will presumably be little variance in the air dose rate, measurements may also be taken in approximately five locations that have been uniformly dispersed). The need to conduct decontamination and the contents of this shall be determined based on the mean values from this. • For school buildings, measurements shall be carried out in approximately five measurement points at places where people are deemed likely to spend relatively large amounts of time in the vicinity around school buildings. The need to conduct decontamination and the contents of this shall be determined based on the mean values from this. For the school building as a whole, measurements can be carried out at multiple points in places where people are deemed likely to spend relatively large amounts of time (roughly the total from the several measurement points in the schoolyard and school building mentioned above), and the need to conduct decontamination and the contents of this can be determined based on the mean values from this.	Same as with No. 1 measurement points. (①)

	【Farmland and pastureland】 • Farmland and pastureland shall be divided up into meshes of about 10 –30 m and measurements shall be conducted at one spot in each mesh. However, changes can be made to this in cases where said land has a vast surface area according to the conditions. The need to conduct decontamination and the contents of this shall be determined based on the mean values from this.	

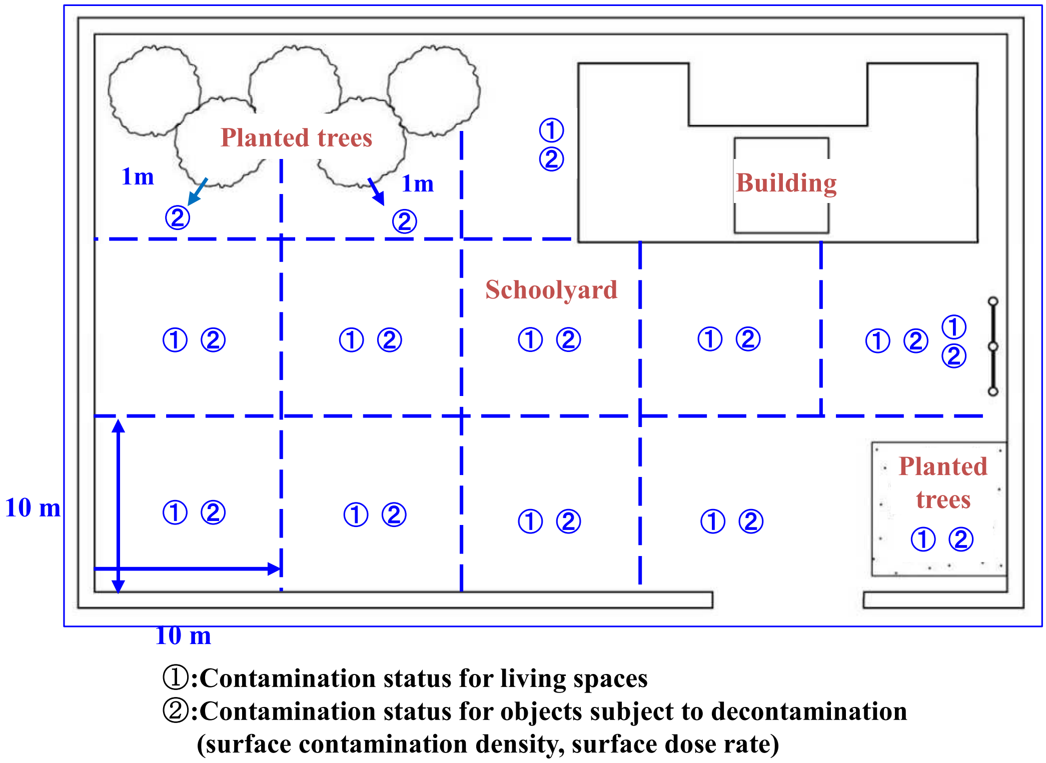


Figure 2-26 Example of a schematic diagram for reporting measurement points for use in decontamination and other measures for soil (schoolyards).

2) Measurement methods

It is recommended that for the measurement point marked as ① the apparatuses such as NaI scintillation survey meters which are able to measure gamma rays should be used and for the measurement point marked as ②, GM survey meters should be used. Table 2-33 presents measurement methods specifically for radiocesium concentration in farmland soil.

Table 2-33 Measurement methods for the radiocesium concentration in farmland soil

Measuring apparatus used	• Estimates from germanium semiconductor detectors, NaI scintillation spectrometers, LaBr3(Lanthanum bromide) scintillation spectrometers, and air dose rate
Calibration	• At least once a year, calibration shall be performed using standard radiation sources with known amounts of radioactivity.
Daily check	• The remaining battery level, breakage of cables and connectors, and status of high voltage application shall be checked, and inspections of switch operability, etc. shall be carried out. • Measurements shall be performed at the same places where the background radiation does not vary substantially, and it shall be confirmed that there are no large variations by comparing with past values.
Prevention of contamination	• ・The body and detecting element of the measuring apparatus shall be covered with thin plastic sheet, etc. • The plastic sheet, etc. shall be replaced with new material when it gets dirty or breaks.
Measurement	• For rice fields, soil shall be extracted from the surface of the measurement point down to 15 cm deep in the ground, and after the soil has been dried the radiocaesium concentration in the soil shall be measured using a germanium semiconductor detector. • For dry fields, soil shall be extracted from the surface of the measurement point down to the depth of the plow layer (15 to 30 cm), and after the soil has been dried the radiocaesium concentration in the soil shall be measured using a germanium semiconductor detector.
Records	• The measurer shall record the air dose rate, etc. and radiocaesium concentration at each measurement point shown in the conceptual diagram, etc., along with the date and time of measurement and the measuring apparatus used.

(3) Decontamination methods

This section explains the flow of the overall decontamination work for soil (Figure 2-27) that is efficiently focused on the places with comparatively high concentrations of radioactive materials that contribute substantially to the radiation dose. The arrangement of the overall schedule should be made so as to avoid undertaking decontamination of two or more large areas within a municipality at the same time whenever possible. The methods of decontamination for soil in schoolyards, kindergarten yards, and parks, as well as farmland are described in terms of the items such as basic flow, necessary measures for prior decontamination work and decontamination methods and notes of caution.

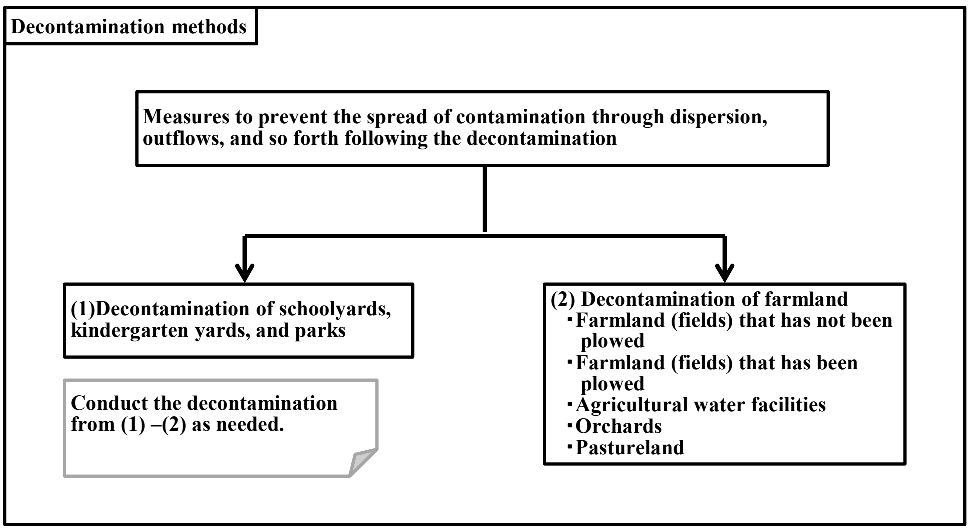


Figure 2-27 Basic flow for the decontamination of soil.

1）Decontamination of soil in schoolyards, kindergarten yards, and parks

The flow of decontamination for soil in schoolyards, kindergarten yards and parks is shown in Figure 2-28. The necessary measures prior to the decontamination work are in Table 2-34. The decontamination methods and notes of caution are in Table 2-35.

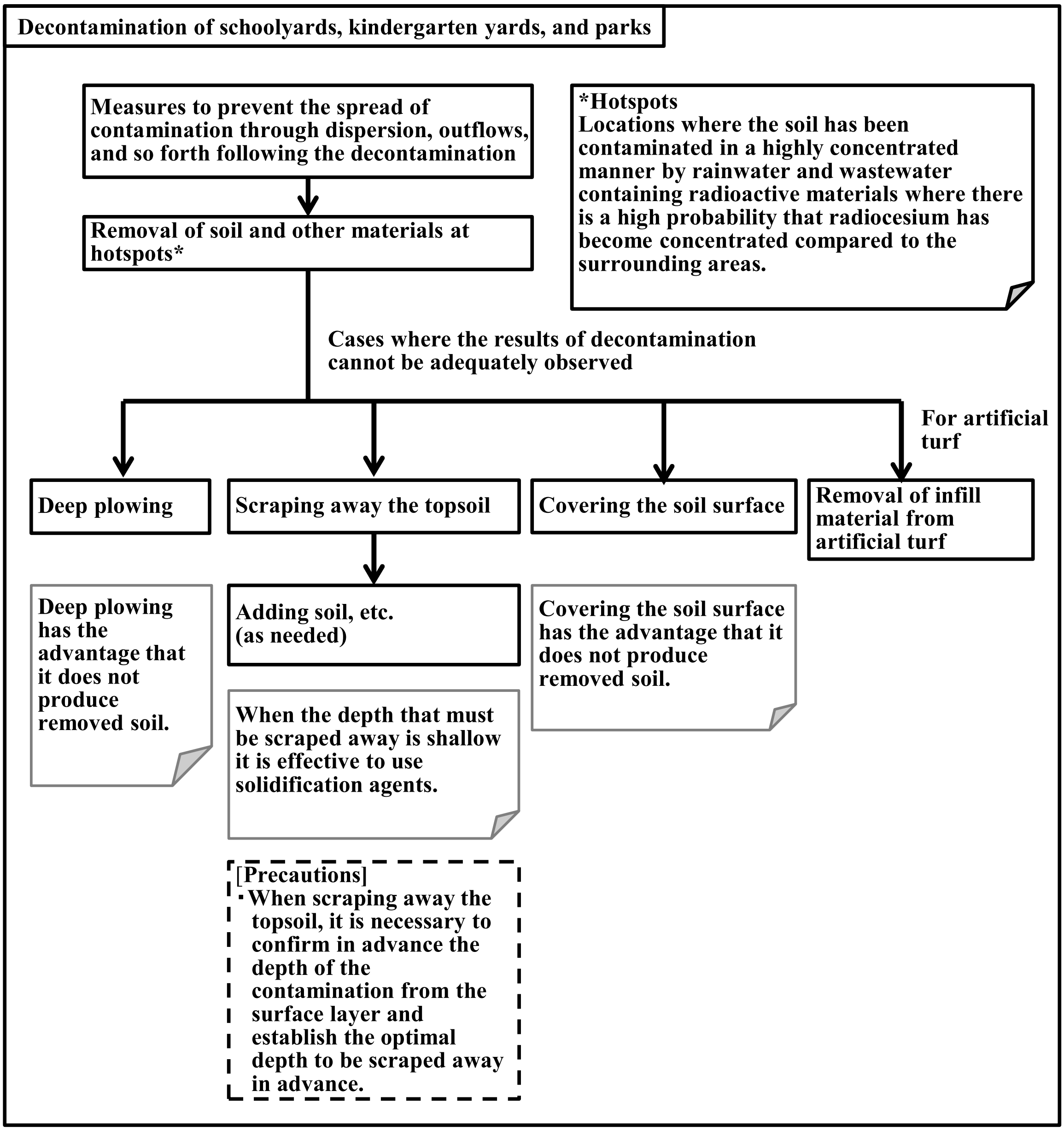


Figure 2-28 Basic flow for the decontamination of schoolyards, kindergarten yards, and parks.

Table 2-34 Necessary measures prior to the decontamination of schoolyards, kindergarten yards, and parks

Category	Decontamination methods and notes of caution
Prevention of dispersion	• When scraping away the topsoil when it comes to dried soil, efforts can be made to prevent the dispersion of dust by scattering solidification agents over the area in advance to solidify the soil surface.

Table 2-35 Decontamination methods for schoolyards, kindergarten yards, and parks and notes of caution

Category	Decontamination methods and notes of caution
Removal of sediments	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
Deep plowing	• About 10 cm of topsoil shall be uniformly scraped away and temporarily piled on top of a plastic sheet or the like. • About 20 cm of subsoil shall be uniformly scraped away and piled on top of a separate location from the topsoil. • After the topsoil has been uniformly spread out, the subsoil shall be uniformly spread on top of it and the land will be leveled. It shall be restored to its original height at a compactness that is about the same as it was before.
Scraping away topsoil	• A backhoe or the like shall be used to uniformly scrape away the surface. • The remaining topsoil can be confirmed by means of sprinkling lime around in advance. • Scraping away by using a surface cutter or hammer knife mower is an effective method for covering vast areas. • Dispersion to the surroundings shall be prevented when scraping away contamination. (Example: use of dust collectors, sprinkling in advance, setting up simple plastic housings, etc.)
Covering the surface soil	• The surface soil shall be covered with soil that does not contain radiocaesium. • Attention shall be paid to the fact that because of the large air gaps when covering with crushed stones, density adjustments shall be performed via the appropriate surface compaction.
Removal of infill material from artificial turf	• The infill material found in artificial turf and the like shall be taken out via machinery that can absorb and remove said infill material.

2) Decontamination of farmland

The flow of decontamination for farmland is shown in Figure 2-29. The necessary measures prior to the decontamination work are in Table 2-36. The decontamination methods and notes of caution are in Table 2-37.

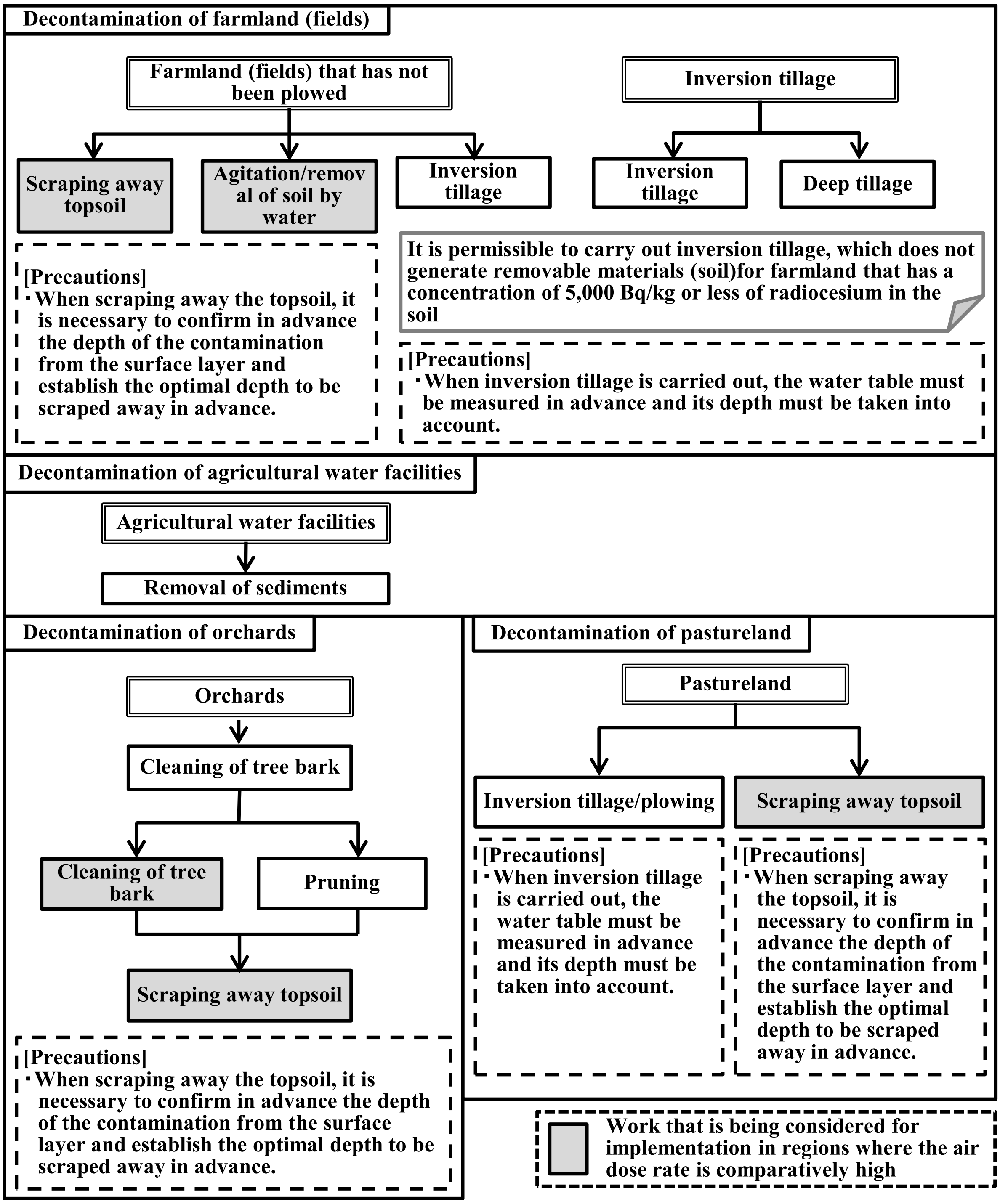


Figure 2-29 Basic flow of decontamination of farmland

Table 2-36 Necessary measures prior to the decontamination of farmland

Category	Decontamination methods and notes of caution
Prevention of dispersion	• When scraping away the topsoil when it comes to dried soil, efforts can be made to prevent the dispersion of dust by scattering solidification agents over the area in advance to solidify the soil surface.

Table 2-37 Decontamination methods for farmland and notes of caution

Category		Decontamination methods and notes of caution
Unplowed	Scraping away topsoil	• A backhoe or the like shall be used to scrape away the surface. • The remaining topsoil can be confirmed by means of sprinkling lime around in advance.
	Soil agitation or removal by water	• After the upper layer of soil has been agitated (shallow puddled), the turbid water with fine soil particles floating in it shall be forcefully drained via a pump. Then solid-liquid separation shall be performed in a grit chamber or similar device that has been covered with a plastic sheet to collect the soil particles.
	Inversion tillage	• A plow shall be used to invert the soil so that the contaminated soil in the top layer is moved to the bottom layer and the uncontaminated soil from the bottom layer is placed on the top layer. • The tillage depth for inversion tillage shall be 30 cm in principal. However, in cases where soil that is not suitable for use as the plow layer will come to the surface, such as soil that contains pebbles, then the tillage depth shall be set shallowly after first confirming that adequate decontamination results will be obtained from this. • The water table shall be measured and its depth taken into account when performing inversion tillage as needed. • Attention must be paid to the fact that small tractors cannot be used to agitate the soil in cases where the topsoil is frozen due to cold temperatures.
Plowed	Inversion tillage	• (Same as above)
	Deep tillage	• A deep tillage rotary tiller shall be used to deeply till cultivated land about two times. The tillage depth of deep tillage shall be about 30 cm in principal.
Water facilities	Removal of sediments	• Mud and other sediments that have accumulated in agricultural drainage canals and other such facilities shall be removed through the use of a shovel or the like.
Orchards	Debarking	• Tree bark shall be removed by primarily concentrating on the top sand sides of main trunks and main branches. • A dedicated chipping tool shall be used to scrape away so as to take off tree bark that has grown old.
	Cleaning tree bark	• Tree species that do not have a configuration in which old tree bark can be removed from their branches and trunks (peach trees, cherry trees, etc.) shall be subject to cleaning. • When cleaning bark or debarking with the use of a high pressure water cleaner, radiocaesium tends to easily disperse together with the water, and so the use of these procedures shall be avoided during the growing season and be carried out during dormant stages.

	Pruning	• Old branches to which it is thought that radiocaesium is directly • Adhering shall be removed. • The branches shall be removed during the tree's dormant stage so that this does not affect its growth.
	Scraping away topsoil	• The soil shall be removed by human power or via an earth blade on a small backhoe. Or a rotary tiller shall be attached to a small tractor and the soil shall be lightly tilled, after which the topsoil shall be removed by a method such as gathering up the topsoil through the use of a front loader (without a claw) on a tractor.
Pastureland	Inversion tillage / plowing	• A plow shall be used to invert the soil so that the contaminated soil in the top layer is moved to the bottom layer and the uncontaminated soil from the bottom layer is placed on the top layer. • The tillage depth for inversion tillage shall be 30 cm in principal. However, in cases where soil that is not suitable for use as the plow layer will come to the surface, such as soil that contains pebbles, then the tillage depth shall be set shallowly after first confirming that adequate decontamination results will be obtained from this. • The water table shall be measured and its depth taken into account when performing inversion tillage as needed. • Attention must be paid to the fact that small tractors cannot be used to agitate the soil in cases where the topsoil is frozen due to cold temperatures.
	Scraping away topsoil	• ・A backhoe or the like shall be used to scrape away the surface.

(4) Post–work measures

This section explains handling the removed soil, etc., and cleaning equipment used, etc. as post-work measures. Handling the removed soil, etc. is described in 2.2.2 (4) 1) of this report and cleaning equipment used, etc.is described in 2.2.2 (4) 3) of this report.

(5) Subsequent measurements and records

To confirm the decontamination effect, the air dose rate, etc. should be measured after completion of the decontamination work and recorded as shown in Table 2-38.

Table 2-38 Subsequent measurements and records for the decontamination of soil

Measurement of air dose rate, etc. and radiocaesium concentration, etc.	• The air dose rate, etc. and radiocaesium concentration in the soil (in the case of farmland) shall be measured at each measurement point. • Measurements shall be carried out in the same location as the prior measurements and under the same conditions to the extent possible. • For the measuring apparatus, the same apparatus as was used for the prior measurements shall be used to the extent possible.
Recordkeeping	• Air dose rate, etc. and radiocaesium concentration in the soil at each measurement point, places for which decontamination work was performed, date of decontamination, names of decontaminators, types of objects subject to decontamination, method of decontamination, total

	area decontaminated (soil, etc.), the approximate weight of the removed soil, etc., and the status of storage and disposal. • The equipment used in decontamination and the method of disposal after use. • See "Part 4: Guidelines Pertaining to the Storage of Removed Soil" for details on the items to record with regard to the storage of removed soil.

2.2.5. Decontamination and Other Measures for Vegetation

This section explains preparation, prior measurements, decontamination methods, post-work measures, and subsequent measurements and records, in the basic flow (Figure 2-30), pertaining to the decontamination and other measures for vegetation.

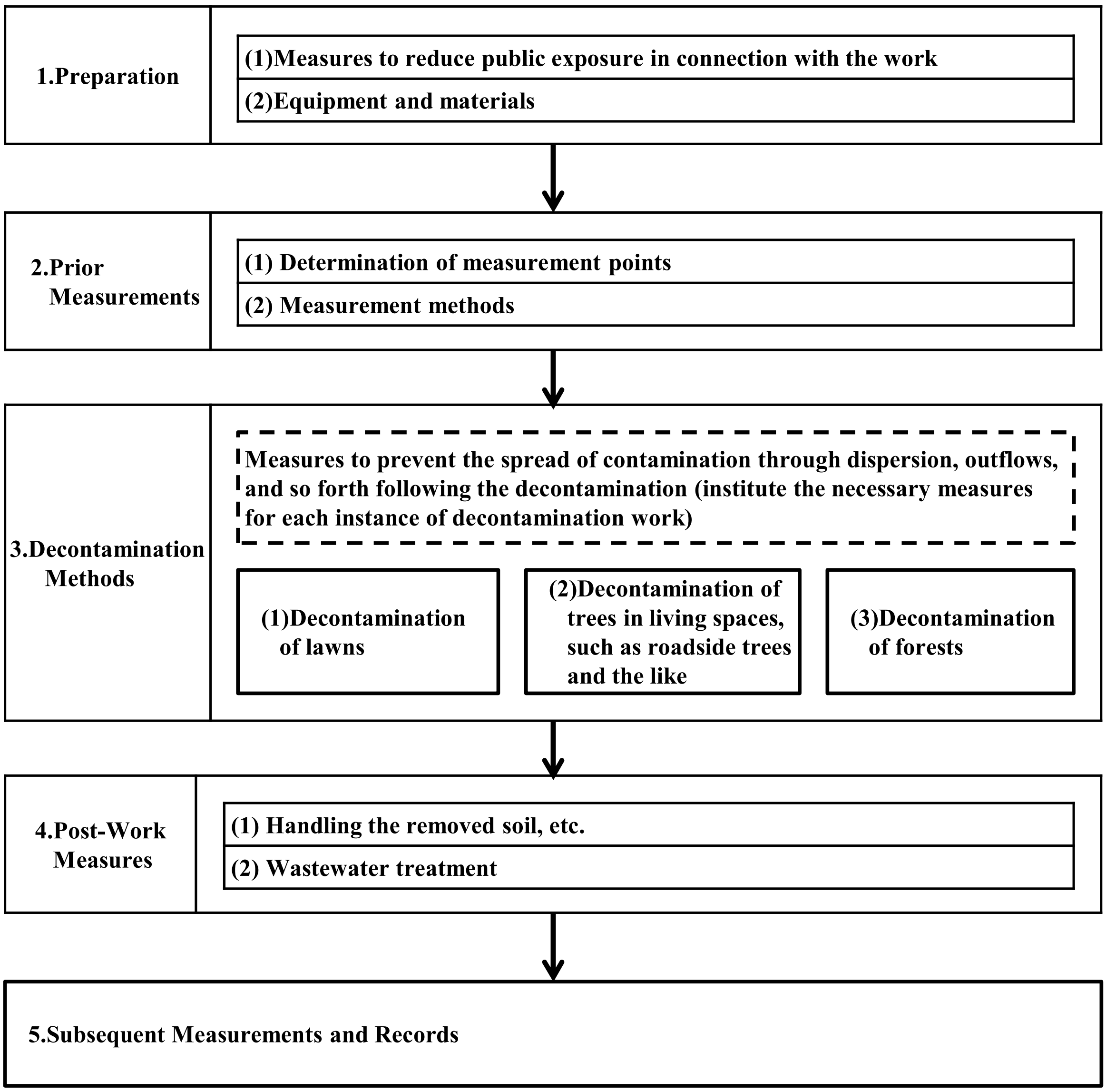


Figure 2-30 Basic flow for decontamination and other measures for vegetation.

（1） Preparation

Before performing decontamination work, in addition to preparing the equipment required for the work, preparations must be made to ensure safety of workers and the general public to prevent their exposure to hazards, such as by inhaling dust generated during decontamination work; these preparations are summarized in Table 2-39.

Table 2-39 Preparation for measures on decontamination work for vegetation

Measures to reduce public exposure in connection with decontamination work	Restriction of entry	• In cases where the general public is deemed likely to enter the area, the area shall be cordoned off with pylons or rope, etc. to prevent people from unnecessarily approaching the work site, and the entry of people and vehicles shall be restricted. • In cases where radioactive materials may be dispersed in connection with the decontamination work, the perimeter of the decontamination area shall be fenced in with sheets, etc., water shall be sprayed, or other such measures shall be taken to prevent dispersion and the area shall be cordoned off with rope, etc.
	Signage	• In cases where the general public is deemed likely to enter the area, signs, etc. shall be put up to alert the public that decontamination work is being performed
Preparation of Equipment and Materials	General equipment	Examples： Mower, hand shovel, grass sickle, broom, bamboo rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags)), vehicles for transporting collected removed soil, etc. to the on-site storage location (truck, two-wheeled cart, etc.)
	equipment for pruning trees	Examples： Hatchet, pruner, chainsaw, stepladder, mobile lift, and saw

（2） Prior measurements

The air dose rate, etc. should be measured and recorded at the same location and by the same method both before and after decontamination work in order to confirm decontamination effects. The method of measurement for the air dose rate, etc. before decontamination work is explained below.

1）Determination of measurement points

Before decontamination work, the measurement points (Table 2-40) at which the air dose rate, etc. are to be measured should be decided and a schematic diagram illustrating the range of the measured objects, the measurement points, structures to be used as markers, etc. should be made (Figure 2-31). In addition, in setting these measurement points, hotspots and their ambient areas that contribute insubstantially to the radiation dose in the living space should not be used as measurement points unless the users, etc. are deemed likely to spend relatively large amounts of time there.

Table 2-40 Reasoning behind the measurement points for air dose rates and other measures for the decontamination of vegetation

Measurement point	No. 1 measurement points （①）	No. 2 measurement points （②）
Measurement target	Air dose rate in living spaces	Surface contamination density, etc. for objects subject to decontamination
Reasoning behind the measurement points	• Measurement points shall be set at intervals that allow the air dose rate distribution to be ascertained. Lawns • Lawns shall be divided up into meshes of about 10 –30 m and measurements shall be conducted at one spot in each mesh. Forests • Measurements shall be conducted at one spot about every 20 –50 m near the forest edge and the geographical center of the forest where work will be performed.	• Same as with No. 1 measurement points （①） for lawns. • For roadside trees, measurement points shall be established within a range that will presumably be affected by the roadside tree (example: a position that is about 1 m away from the side of the roadside tree). • For forests, the points shall be as with No. 1 measurement points.

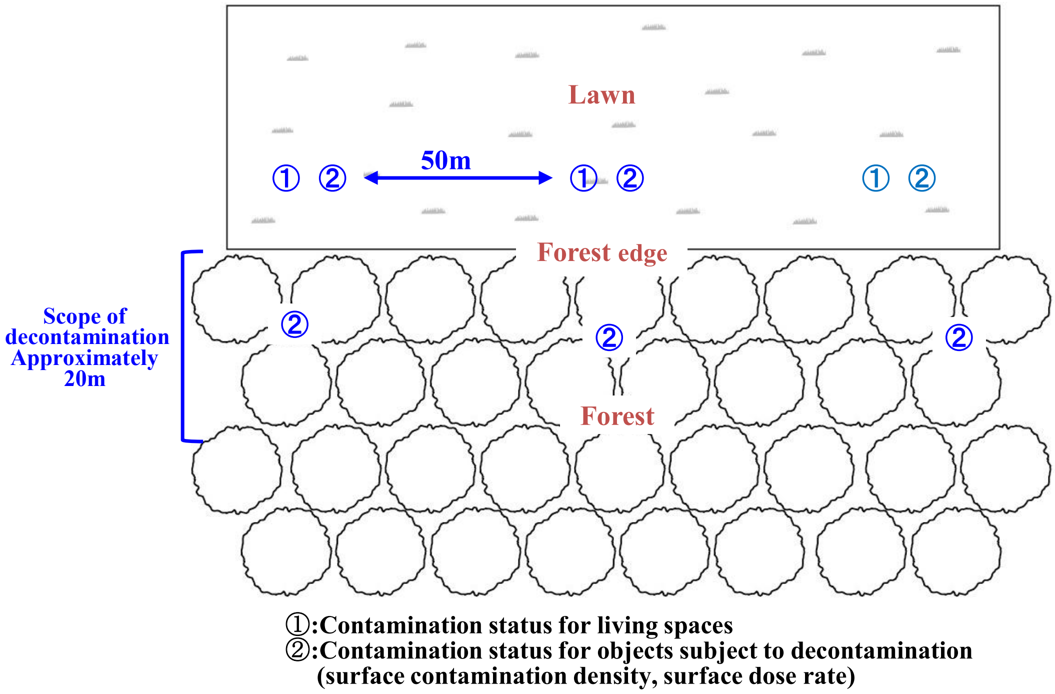


Figure 2-31 Example schematic diagram for reporting measurement points for use in decontamination and other measures for vegetation (forests).

2）Measurement methods

It is recommended that for the measurement point marked as ① the apparatuses such as NaI scintillation survey meters which are able to measure gamma rays should be used and for the No. 2 measurement point marked as ②,GM survey meters should be used..

(3) Decontamination Methods

The flow of decontamination for vegetation is explained in Figure 2-32. The necessary measures prior to the decontamination work are in Table 2-41. The decontamination methods and notes of caution are in Table 2-42.

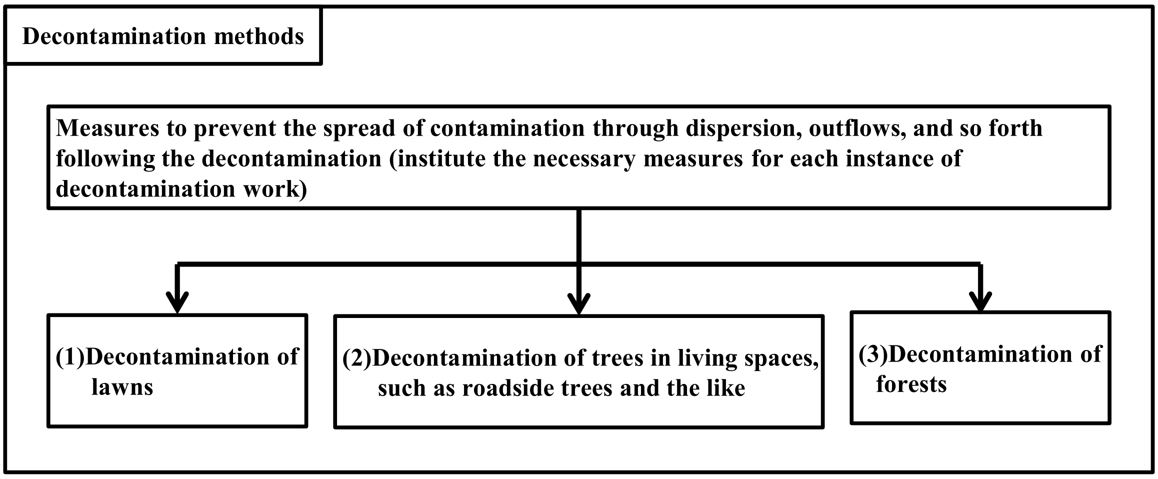


Figure 2-32 Basic flow for the decontamination of vegetation.

1) Decontamination of lawns

The flow of decontamination for lawns is in Figure 2-32. The necessary measures prior to the decontamination work are in Table 2-41. The decontamination methods and notes of caution are in Table 2-42.

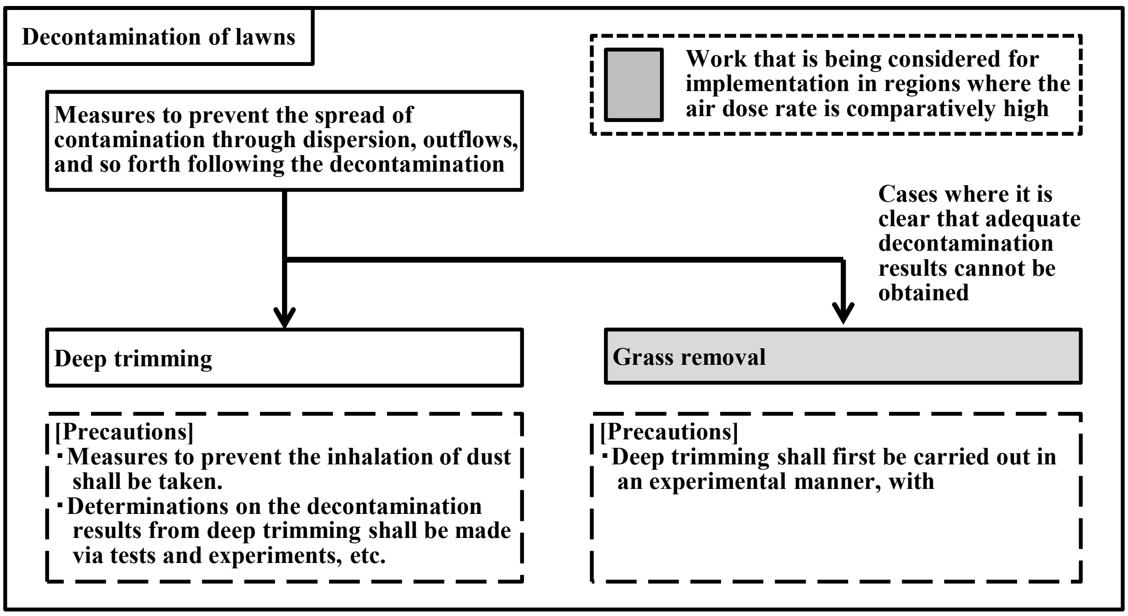


Figure 2-33 Basic flow for the decontamination of lawns.

Table 2-41 Necessary measures prior to the decontamination of lawns

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent the dispersion of dust, etc.

Table 2-42 Decontamination methods for lawns and notes of caution

Category	Decontamination methods and notes of caution
Deep trimming	• If large mowers will fit, then deep trimming shall be carried out using large mowers (shallow cutting down to approximately 3 cm, which is a level from which the grass can recover). • If large mowers will not fit, then the deep trimming of lawns shall be carried out using a hand guided mower (sod cutter, etc.)
Grass removal	• The flat claw for a backhoe bucket shall be installed and the grass and sod shall be removed (about 5 cm).

2) Decontamination of trees in living spaces, such as roadside trees and the like

The flow of decontamination for trees in living spaces, such as roadside trees and the like is explained in Figure 2-34. The necessary measures prior to the decontamination work are in Table 2-43. The decontamination methods and notes of caution are in Table 2-44.

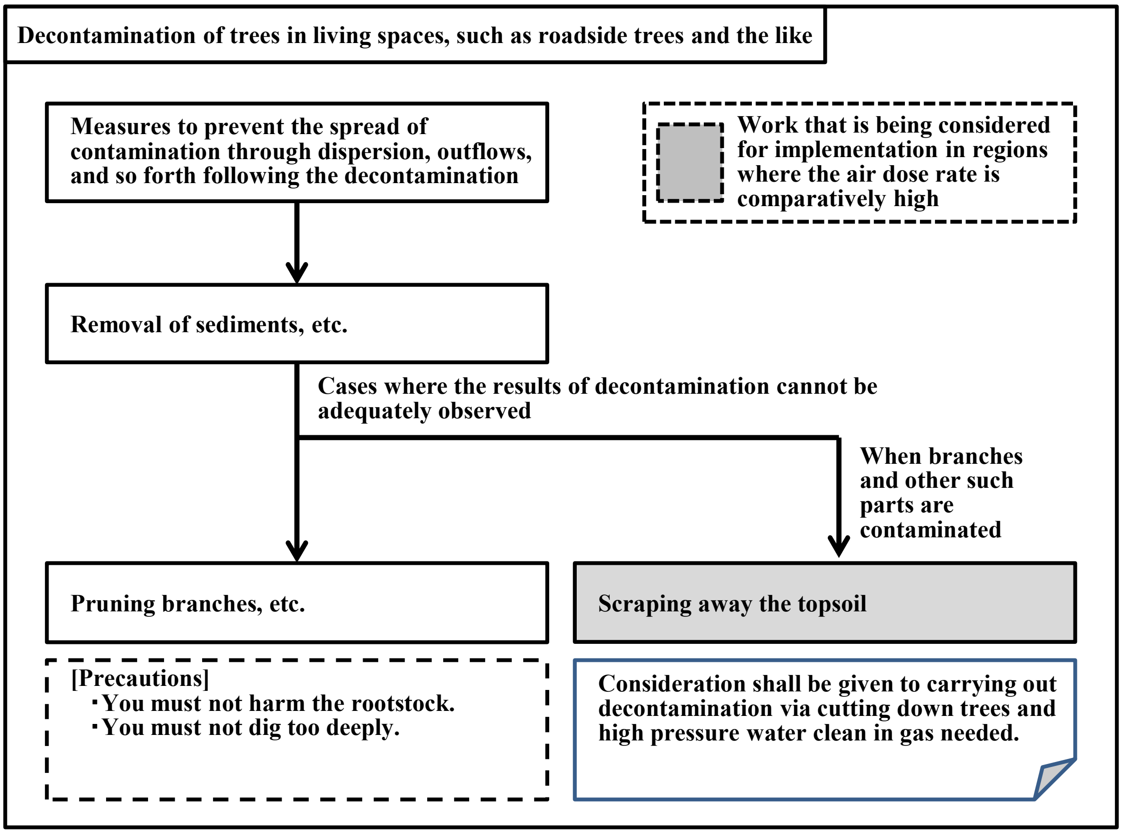


Figure 2-34 Basic flow for the decontamination of trees in living spaces, such as roadside trees and the like.

Table 2-43 Necessary measures prior to the decontamination of trees in living spaces, such as roadside trees and the like

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent the dispersion of dust, etc.

Table 2-44 Decontamination methods for trees in living spaces, such as roadside trees and the like and notes of caution

Category	Decontamination methods and notes of caution
Removal of sediments	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
Scraping away topsoil	• Accumulated fallen leaves and soil shall be picked up by using a shovel or rake, etc.
Removal of branches, etc.	• Delimbing and pruning shall be carried out on roadside trees by using a pruner and branch cutter to an extent that does not give rise to any pronounced impact for the growth of trees according to the tree species and their delimbing period.

3) Decontamination of forests

The flow of decontamination for forests is explained in Figure 2-35. The necessary measures prior to the decontamination work are in Table 2-45. The decontamination methods and notes of caution are in Table 2-46.

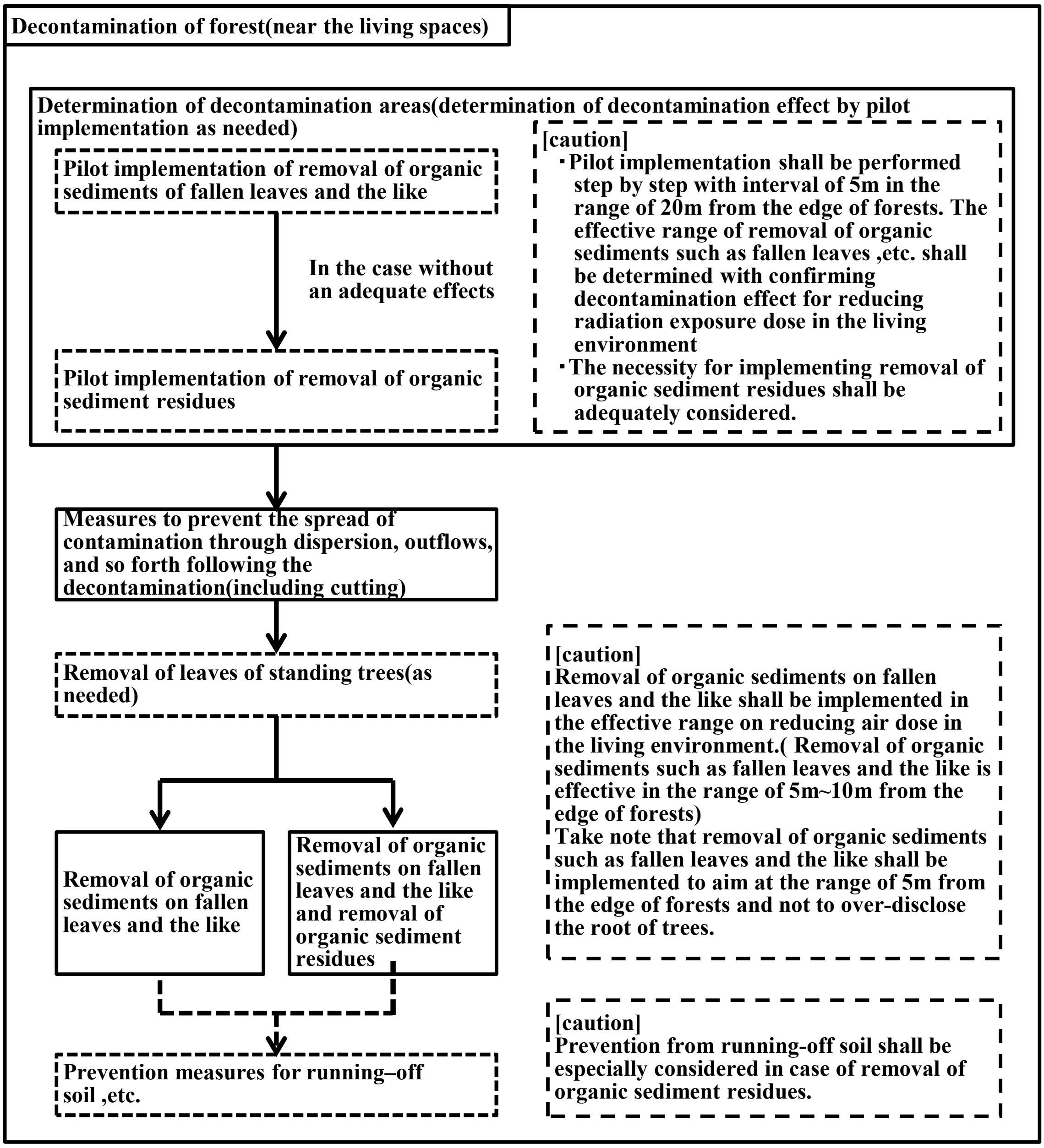


Figure 2-35 Basic flow of decontamination of forests (near living spaces).

Table 2-45 Necessary measures prior to the decontamination of forests

Category	Necessary measures prior to the decontamination
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent the dispersion of dust, etc.
Cutting	• The cutting of weeds, shrubs, and other vegetation shall be carried out using a chainsaw or shoulder-type mower, etc.

Table 2-46 Decontamination methods for forests and notes of caution

Category	Decontamination measures and notices of caution
Removal of organic sediment	• Organic sediment shall be removed by bamboo-rake, etc. • Masks shall be worn to avoid inhaling suspended particulates produced during removal work.
Removal of organic sediment residue	• Organic sediment residue shall be removed by bamboo-broom, etc.if radiation dose is not effectively able to be reduced in the living environment after removal of organic sediment. • Masks shall be worn to avoid inhaling suspended particulates produced during removal work.
Removal of branches and leaves (only for evergreen trees)	• In case that a large contribution of radiation materials on the standing trees at the very edges of the peripheral areas around forests to radiation exposure dose in the living environment is deemed , the pruning and cutting of branches and leaves of standing trees at the very edges of the peripheral areas around forests shall be carried out to an extent that does not give rise to any pronounced impact for the growth of trees and the fallen branches and leaves shall be collected, • Generally, the very edges of the peripheral areas around forests contain a large volume of leaves affixed to trees, and so there is the possibility that a comparatively large amount of radioactive materials are adhering to them. Therefore, branches and leaves should be removed from as high up a position as possible (up to about half the length of the tree canopy). • Masks shall be worn to avoid inhaling suspended particulates produced during removal work.
Prevention measures of running - off soil	• Prevention of running-off soil shall be made by setting sandbags and fences at appropriate locations such as the very edges of the peripheral areas around forests.

(4) Post–work measures

This section explains handling the removed soil, etc., and cleaning equipment used, etc. as post-work measures. Handling the removed soil, etc.is described in 2.2.2 (4) 1) of this report and cleaning equipment used, etc. is described in 2.2.2 (4) 3) of this report.

(5) Subsequent measurements and records

To confirm the decontamination effect, the air dose rate, etc. should be measured after completion of the decontamination work and recorded as shown in Table 2-47.

Table 2-47 Subsequent measurements and records for the decontamination of forests

Measurement of air dose rate, etc.	• The air dose rate, etc. shall be measured at each measurement point. • Measurements shall be carried out in the same location as the prior measurements and under the same conditions to the extent possible. • For the measuring apparatus, the same apparatus as was used for the prior measurements shall be used to the extent possible.
Recordkeeping	• The air dose rate, etc. at each measurement point, places where decontamination work was performed, decontamination date, names of the decontaminators, type of objects decontaminated, decontamination methods, total decontamination area (of soil, etc.), the approximate weight of the removed soil, etc., and the status of storage and disposal. • The equipment used in decontamination and the method of disposal after use. • See "Part 4: Guidelines Pertaining to the Storage of Removed Soil" for details on the items to record with regard to the storage of removed soil.

2.2.6. Decontamination Measures of Rivers and Ponds, etc.

This section explains the basic policy for decontamination measures of rives and ponds, etc. that is, the exposure from radioactive materials in the sediments of rivers and ponds, etc. with a very large amount of water which has an effective shielding effect makes very little contribution to the radiation level of ambient areas. In the case of the seasonal water dried-up condition (which negates the expected shielding effect), for the living spaces where the air dose rate from accumulated radioactive cesium deposited on the sediments is high and many activities of the general public are carried out, the decontamination measures should be implemented as needed. The objectives for decontamination measures are the facilities which the general public often utilizes, such as facilities which are located near riverbeds and areas where there are sediments of rivers and ponds. For the former decontamination measures, the provisions for other specific places may be applied as shown in Table 2-48.

Table 2-48 Specific implementation methods for decontamination work, etc. for facilities located near riverbeds which the general public often utilizes.

objectives	Referred sections in "Decontamination Guidelines"
Fences・walls, benches and playing tools	2.2.2. (3) 4) Decontamination of fences・walls, benches and playing tools
Parts paved by concrete,asphalt ,etc.	2.2.3. (3) 1) Dcontamination of paved surfaces ,etc.
Parts of soil,etc. on ground surface	2.2.3. (3) 2) Decontamination of unpaved roads, etc. 2.2.4. (3) 1) Decontamination of soil of schoolgrounds,kindergaraten,parks
Parts of lawns on ground surface	2.2.5. (3) 1) Decontamiantion of lawns

On the other hand, the sediments of rivers and ponds (reservoirs) should be decontaminated only if the air dose rate increases significantly due to seasonal water dry-up in reservoirs located near living spaces such as residential areas and parks. For decontamination of sediments in reservoirs, the basic flow of decontamination measures is shown in Figure 2-36 and they consist of preparation, prior measurements, decontamination methods, post-work measures, and subsequent measurements and records.

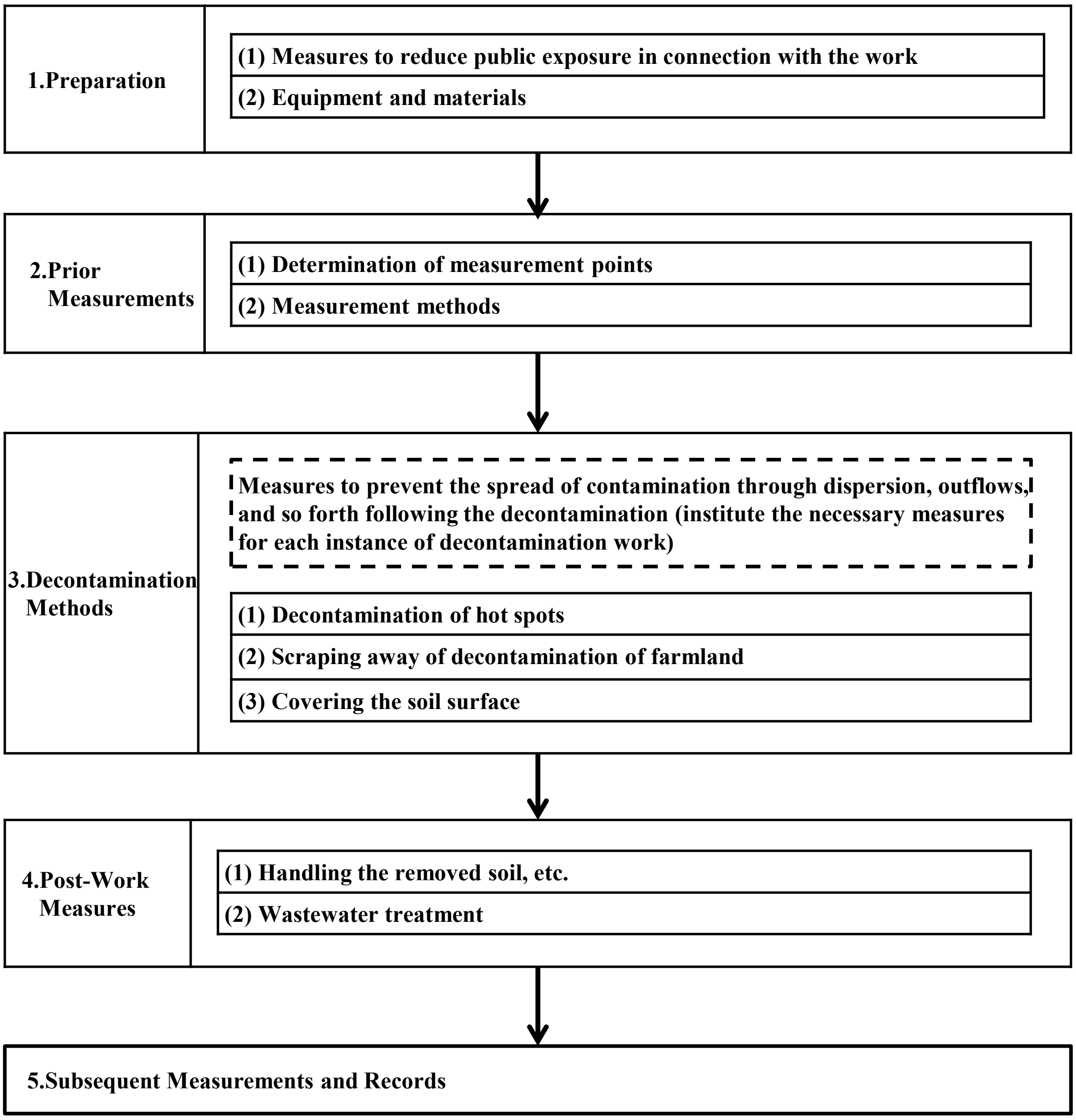


Figure 2-36 Basic flow of decontamination measures of sediments in reservoirs.

（1） Preparation

Before performing decontamination work, in addition to preparing the equipment required for the work, preparations must be made to ensure safety of workers and the general public to prevent their exposure to hazards, such as by inhaling dust generated during decontamination work; these preparations are summarized in Table 2-49.

Table 2-49 Preparation of decontamination measures for sediments in reservoirs

Measures to Reduce Public Exposure in Connection with Decontamination Work	Restriction of entry	• In cases where the general public is deemed likely to enter the area, the area shall be cordoned off with pylons or rope, etc. to prevent people from unnecessarily approaching the work site, and the entry of people and vehicles shall be restricted • In cases where radioactive materials may be dispersed in connection with the decontamination work, the perimeter of the decontamination area shall be fenced in with sheets, etc., water shall be sprayed, or other such measures shall be taken to prevent dispersion and the area shall be cordoned off with rope, etc.
	Signage	• In cases where the general public is deemed likely to enter the area, signs, etc. shall be put up to alert the public that decontamination work is being performed.
Preparation of equipment ,etc.	General equipment	Examples： Mower, hand shovel, grass sickle, broom, bamboo rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags)), large sandbags, flexible containers vehicles for transporting collected removed soil, etc. to the on-site storage location (truck, two-wheeled cart, etc.), ladder
	Equipment for scraping away sediments	Examples: tractor, vertical harrow and other attachments, rear blade, front loader, backhoe, grader, crane, vacuum car, mower, chipping machine, hammer knife mower, flexible containers, bulldozer, hydraulic shovel, backhoe
	Equipment for covering sediments	Examples: Self-propelled surface compaction roller, plywood for surface compaction, sprinkling equipment, bulldozer, hydraulic shovel

（2） Prior measurements

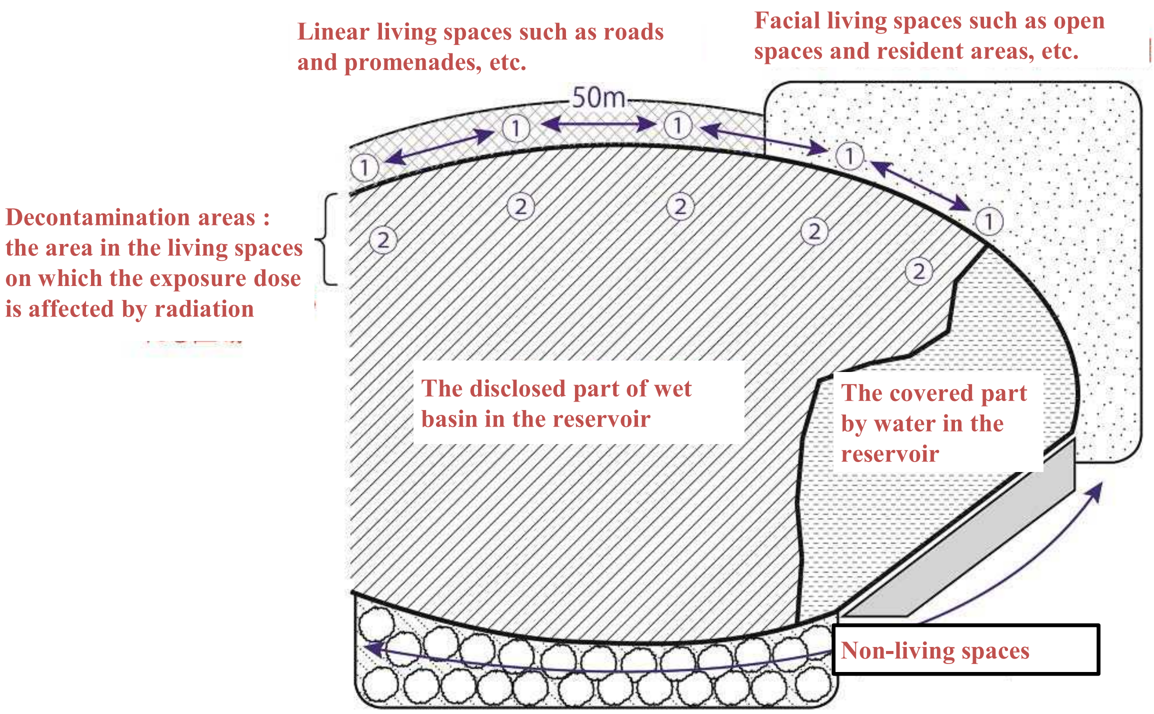
The air dose rate, etc. should be measured and recorded at the same location and by the same method both before and after decontamination work in order to confirm decontamination effects. The method of measurement for the air dose rate, etc. before decontamination work is explained below.

1）Determination of measurement points

Before decontamination work, the measurement points (Table 2-50) at which the air dose rate, etc. are to be measured should be decided and a schematic diagram illustrating the range of the measured objects, themeasurement points, structures to be used as markers, etc. should be made (Figure 2-37). In addition, in setting these measurement points, hotspots and their ambient areas that contribute insubstantially to the radiation dose in the living space should not be used as measurement points unless the users, etc. are deemed likely to spend relatively large amounts of time there..

Table 2-50 Reasoning behind the measurement points for air dose rates and other measures for the decontamination of sediments in reservoirs

Measurement point	No. 1 measurement points(①)	No. 2 measurement points (②)
Measurement target	Air dose rate in living spaces	Surface contamination density, etc. for objects subject to decontamination
Reasoning behind the measurement points	• The measurement points shall be determined with the distance between the points where the distribution of the air dose rate is able to confirm. • In the case that the air dose rate of the living spaces is significantly affected by radiation exposure from dried-up reservoir, the measurement shall be made at a point per the distance-interval of approximately 20m~50m, in the peripheral parts of the reservoir, when the basin of the reservoir is disclosed.	• The measurement shall be made at a point per the distance-interval of approximately 20m~50m, in the dried-up reservoir whose radiation exposure affects the air dose rate in the living spaces near the reservoir.



＊If the living environment will in future be deemed to be affected due to increase of the air dose rate from radiation exposure by in-flow and out-flow of the reservoir after decontamination, decontamination of sediment in the reservoir may , as needed, be implemented and the measuring points shall be determined according to the decontamination area .

① : Status of decontamination on the living space

② : Status of decontamination of decontamination objects

Figure 2-37 Example diagram on measurement points for decontamination of sediments in a reservoir.

2）Measurement methods

It is recommended that for the measurement point marked as ① the apparatuses such as NaI scintillation survey meters which are able to measure gamma rays should be used and for the measurement point marked as ②, GM survey meters should be used.

（3） Decontamination methods

This section explains that the decontamination methods should be implemented so as to prevent contamination expansion due to dispersion and outflow of radioactive substances caused by the decontamination work. The decontamination flow for the reservoir is shown in Figure 2-38. The necessary measures prior to the decontamination work are in Table 2-51. The decontamination methods and notes of caution are in Table 2-52.

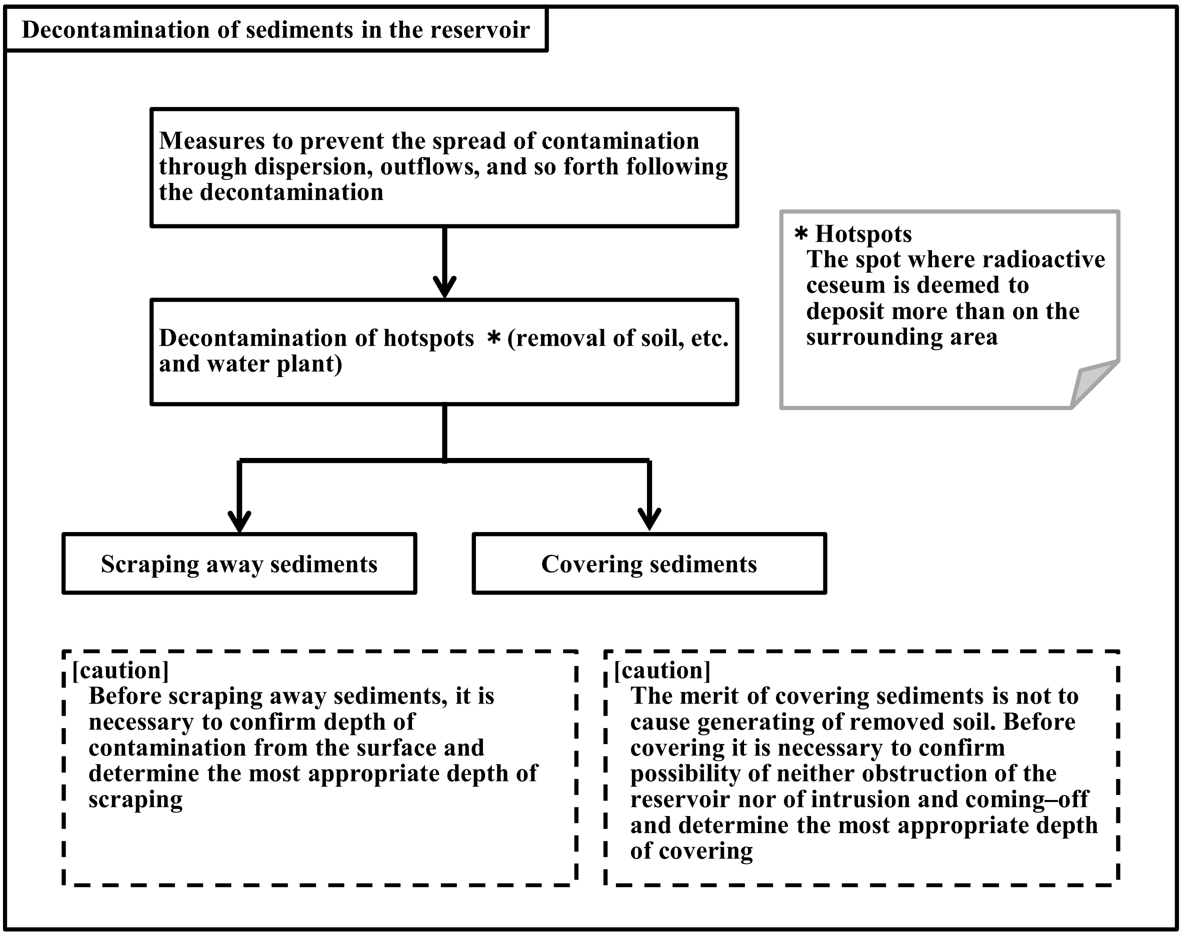


Figure 2-38 Basic flow of decontamination of sediments in reservoirs.

Table 2-51 Necessary prior measures for decontamination of sediments in reservoirs

category	Necessary prior-measures
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent the dispersion of dust, etc. • If scraping topsoil of dried-up soil, prevention measure of dispersion of soil dust shall be implemented. There are the measures of solidifying the surface of the soil in advance by dispersing solidifying materials,etc.

Table 2-52 Decontamination methods for sediments in reservoirs and notes of caution

Category	Decontamination methods and notices of caution
Decontamination of hotspots	• Sediments and water plants shall be removed by hand with rubber-gloves and scoop.it is recommended that top sediment is scraped every approximately several centimeter with measuring surface contamination density etc.
Scraping and removal of sediments	• Before scraping sediments it is necessary to confirm depth of contamination from the surface and determine the most appropriate depth of scraping • It is recommended that for a small area in the appropriate location of the reservoir, top sediment shall be scraped every several centimeter depth of sediments with measuring surface contamination density and the depth to be scraped shall be determined. • Sediments shall be scraped by backhoe, etc. • It is able to confirm whether the residue of top sediments not to be removed exist by dispersing in advance calcium arsenate ,etc.
Covering sediments	• Sediments shall be covered by soil without radiocaesium while it shall be taken account into that covering layers over the sediments are run-off and the sediments are disclosed by the water flow after re-filling water ,etc.

(4) Post–work measures

This section explains handling the removed soil, etc., and cleaning equipment used, etc. as post-work measures. Handling the removed soil, etc. is described in 2.2.2 (4) 1) of this report wastewater treatment, in 2.2.2 (4) 2) of this report and cleaning equipment used, etc., in 2.2.2 (4) 3) of this report.

(5) Subsequent measures and records

To confirm the decontamination effect, the air dose rate, etc. should be measured after completion of the decontamination work and recorded as shown in Table 2-53.

Table 2-53 Subsequent measurements and records of decontamination for sediments in reservoirs

Measurement of air dose rate, etc.	• The air dose rate, etc. and radiocaesium concentration in the soil (in the case of farmland) shall be measured at each measurement point. • Measurements shall be carried out in the same location as the prior measurements and under the same conditions to the extent possible. • For the measuring apparatus, the same apparatus as was used for the prior measurements shall be used to the extent possible.
Recordkeeping	• Air dose rate, etc. and radiocaesium concentration in the soil at each measurement point, places for which decontamination work was performed, date of decontamination, names of decontaminators, types of objects subject to decontamination, method of decontamination, total area decontaminated (soil, etc.), the approximate weight of the removed soil, etc., and the status of storage and disposal. • The equipment used in decontamination and the method of disposal after use. • See "Part 4: Guidelines Pertaining to the Storage of Removed Soil" for details on the items to record with regard to the storage of removed soil.

2.3. Guidelines Pertaining to the Collection and Transfer of the Removed Soil

2.3.1. Basic Concept

The "Guidelines Pertaining to the Collection and Transfer of the Removed Soil" use the example cases to explain in a concrete fashion the Ordinance of the Ministry of the Environment pertaining to standards for the collection and transfer of the removed soil provided in Article 41, Paragraph 1 of the Act on Special Measures.

When collecting and transferring the removed soil, safety measures are required to prevent radioactive materials contained in the removed soil from damaging human health and the living environment. The specific, necessary actions include 1) preventing the radioactive materials from dispersing or outflowing when the removed soil is loaded, unloaded, or transferred, and 2) preventing the public from being exposed to radiation emitted from the removed soil while it is being collected or transferred.

These guidelines organize and describe the requirements for collecting and transferring the removed soil as well as specific actions to be taken in accordance with the safety measures mentioned above while also referring to the existing rules related to the transfer of radioactive materials[79].

2.3.2. Requirements for Collection and Transfer of the Removed Soil

This section explains four types of requirements for collection and transfer of the removed soil.

- Requirements for Preventing Dispersion, Outflow, and Leakage
- Requirements for Radiological Protection
- Requirements for the Transfer Route
- Other Requirements

2.3.3. Specific Actions

Specific actions are necessary to collect and transfer the removed soil by using trucks in view of the requirements listed in 2.3.2.

- Preventing Dispersion, Outflow, and Leakage
  - ✓ When collecting and transferring the removed soil, it is put into flexible container bags, flexible containers, or drums with a lid, or wrapped in plastic sheets, etc. No other special measures are necessary if the soil is transferred by box trucks.
  - ✓ If the removed soil contains sharp or heavy materials such as relatively large stones, the containers should be prevented from being torn, for example by using containers with an inner liner.
  - ✓ Before the transfer of removed soil with a high water content, it is dehydrated as much as possible and measures are taken such as putting the soil in impermeable containers or laying down waterproof sheets.
  - ✓ When using non-waterproof containers, measures should be taken such as covering the removed soil with waterproof sheets to prevent rainwater from permeating the soil during collection and transfer. No such measures are necessary when using

[79]The ministerial ordinances based on the Act on the Regulation of Nuclear Source Materials, Nuclear Fuel Materials and Reactors (hereinafter the "Reactor Regulation Act"), which includes the "Rules Related to the Transfer of Nuclear Fuel Materials Outside Plants or Operating Sites (hereinafter the "external transfer rules")" and "Rules for Transferring Nuclear Fuel Materials by Vehicles (hereinafter the "vehicle transfer rules for nuclear fuel materials")," as well as the ministerial ordinance based on the Act on the Prevention of Radiation Hazards Due to Radioisotopes, etc. (hereinafter the "Prevention Act"), which includes the "Rules for Transferring Radioisotopes by Vehicles (hereinafter the "vehicle transfer rules for radioisotopes")".

box trucks.

- ✓ All containers should be visually checked for tears or cracks and the mouths of any flexible bags or flexible containers should be securely close to prevent the contents from being discharged if they collapse or fall over, or a fire breaks out. Drums should be selected that have locking mechanisms.
- ✓ Before driving a truck from an on-site storage area or a temporary storage site for removed soil on public roads, the exterior and tires of the truck should be washed if any soil is adhering to the truck. If water is used for washing, the drainage channel for the washing water should be checked in advance to ensure smooth drainage and if necessary, it should be cleared.
- ✓ Fire extinguishers should be kept in the trucks as a means of controlling any fires. Moreover, for the handling of any removed soil that has spilled out, the following items should be prepared: cleanup implements, bags for collection, barrier ropes or tapes to indicate the areas where people should not enter, flashlights, and communication devices such as mobile phones. If the carrier is a business operator, it is recommended a measuring apparatus be carried to check for radioactive contamination (calibrated scintillation survey meter).

- Shielding
  - ✓ When transferring the removed soil from areas where the radioactive dose rate exceeds 200 mSv/year, a calibrated scintillation survey meter (hereinafter referred to as the “measuring apparatus”) should be used to measure the air dose rate around the truck after it is loaded with containers.
  - ✓ The measuring apparatus should be covered with a plastic bag to avoid contamination.
  - ✓ The detecting element should be held parallel to the ground surface during measurement.
  - ✓ After turning on the power of the measuring apparatus, it is necessary to wait until the readings become stable. After that, readings should be taken five times and the average of these values will be the measured value.
  - ✓ The measurements should be taken at a point 1 m from the front, rear, and both sides of the vehicle. If there is an open cargo area, the vertical planes of the external outline of the carried objects should be used instead of both sides of the vehicle.
  - ✓ Measurements should be conducted at the point where the highest air dose rate is observed after implementing an initial screening on each surface of the vehicle. If the point of the highest air dose rate is unknown, the measurements should be taken at the center of each surface.
  - ✓ Care should be taken that the maximum measured values (dose equivalent rates at 1 cm) does not exceed 100 μSv/hour, and the results should be recorded.
  - ✓ If the maximum dose exceeds 100 μSv/hour, the amount of the removed soil to be transferred should be decreased or shielding materials should be added to the containers holding the soil or to the truck itself.

- Loading limitations
  - ✓ If the removed soil is loaded together with other wastes on a truck, the two should be distinguished from each other during the collection and transfer.

- Signage
  - ✓ Collection and transfer of the removed soil using trucks shall be conducted in the following manner.

A. The following information should be displayed on the exterior of the truck.
  (1) Precautions to the effect that the truck is being used to collect or transfer removed soil.
  (2) Name of the person or entity in charge of the collection or transfer.

B. The information provided in items (1) and (2) above should be indicated using signage with easily identified colors and letters. The letter size of the precautions as provided under (1) should be not less than 140 points as specified in JIS Z 8305, and the letter size of the precautions as provided under (2) should be not less than 90 points as specified in JIS Z 8305.

✓ Transfer during the night should be avoided as much as possible. This is because visibility generally deteriorates at night, and so for example it would be harder to see the signage that is being displayed.

- Other matters

  ✓ Documents showing the following information should be kept in the truck.
  (These apply when any of the national, prefectural, and municipal governments conducts or commissions a carrier to conduct the collection or transfer of the removed soil.)

  - As a document to prove this fact, a copy of the contract between the government and the contractor (concerned party).
  - Name and address of the person in charge of the collection or transfer and the name of the representative if the carrier is a corporation.
  - Amount of the removed soil to be collected or transferred.
  - Date on which collection or transfer is started.
  - Names, addresses, and contacts of the sites where the removed soil is being loaded for the collection or transfer, and of the destination where the soil is being transferred to.
  - Cautions pertaining to handling the removed soil.
  - Emergency measures in case of an accident.

  <u>(When the carrier (primary contractor) that has been commissioned by the National Government to collect or transfer the removed soil commissions such work to another carrier)</u>

  - As a document to prove this fact, a copy of the contract between the primary contractor and the carrier (subcontractor).
  - A document proving the fact that said subcontractor is the person who has been listed as those to whom the said primary contractor intends to subcontract the work of collection and transfer of the removed soil under the contract document pertaining to the agreement made between the National Government and the primary contractor.
  - Name and address of the person in charge of the collection or transfer and the name of the representative if the carrier is a corporation.
  - Amount of the removed soil to be collected or transferred.
  - Date on which collection or transfer is started.
  - Names, addresses, and contacts for the site where the removed soil is being loaded for collection or transfer and of the destination where the soil is being transferred to.
  - Cautions pertaining to handling the removed soil.
  - Emergency measures in case of an accident.

- ✓ The carrier should load and unload the removed soil by its own workers or instruct other workers to do this.
- ✓ If there are records on the decontamination work, the document showing the air dose rate on the surface of each bag or container should be kept in the truck.
- ✓ When selecting the transfer route, residential areas, shopping streets, school routes, and narrow roads should be avoided to the extent possible in order to prevent damage to human health and the living environment as well as to reduce any other effects on local residents. Moreover, the removed soil transfer by vehicles should be done while following the legally permitted speeds and avoiding the peak times for heavy traffic and the time periods when children are going to or returning from schools or kindergartens. When the removed soil is being loaded onto the truck, low-noise heavy machinery should be used to reduce noise.
- ✓ The following items should be recorded: the amounts of the removed soil collected or transferred; the dates on which each arrangement for the collection or transfer of the removed soil starts and ends; the name of the person in charge of the collection or transfer; the names and addresses of the sites where the removed soil is loaded and unloaded; and the registration or vehicle number of the truck used for the collection or transfer. The resulting records should be retained for five years from the date when the collection or transfer ends.

2.4. Guidelines Pertaining to the Storage of Removed Soil

These guidelines use example cases to explain in a concrete fashion the Ordinance of the Ministry of the Environment pertaining to standards for the storage of the removed soil provided in Article 41, Paragraph 1 of the Act on Special Measures.

- Facility Design

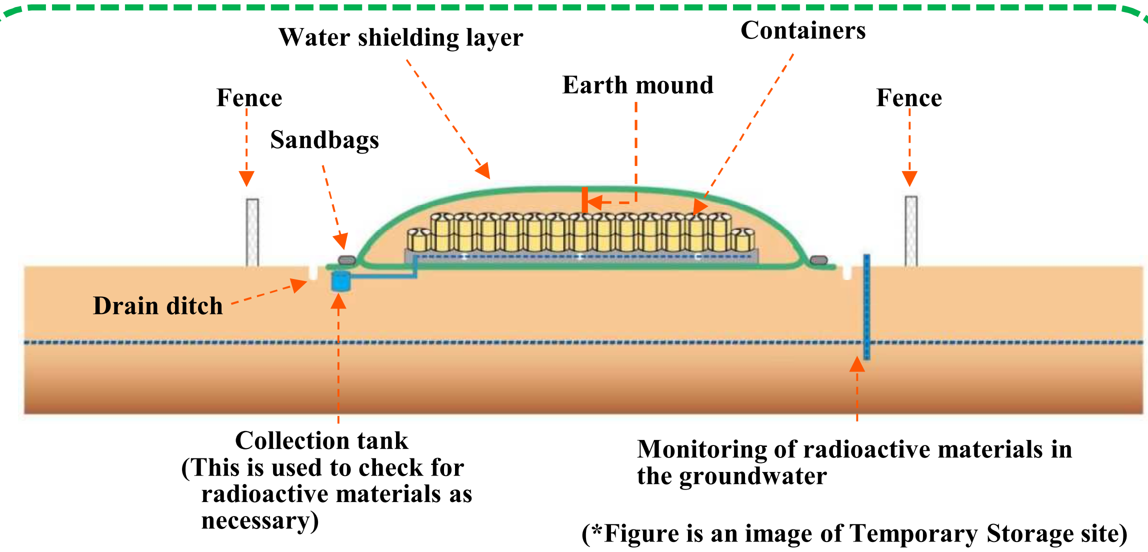
Construction of storage facilities (hereinafter "facilities") that can ensure safety according to the radioactivity concentration and amount of the removed soil

- Safety Management

Carrying out proper safety management of the removed soil during and after its delivery. Taking measures if any problems occur.

2.4.1. Safety Measures and Requirements Necessary for Storage

This section describes organization of the facilities and management requirements based on the safety measures that are considered to be necessary and commonly applied when storing the removed soil (Figure 2-39).



Basic diagram of the safety measures for on-site and temporary storage sites

① Prevent radioactive materials from dispersing, outflowing, or penetrating the ground ---→ (e.g. water shielding layer and containers)
② Block radiation by shielding ---→ (e.g. earth mounds and sandbags)
③ Install fences to prevent intrusion ---→ (e.g. fence)
④ Monitor the air dose rate and groundwater continuously ---→ (e.g. monitoring of radioactive materials)
⑤ Take prompt measures when any abnormality is found.

Note: ③ and ④ apply only to temporary storage sites.

Figure 2-39 Basic diagram of the safety measures for on-site and temporary storage sites.

(1) Facility requirements

The seven following facility requirements are explained.

- Shielding and isolation
- Prevention of dispersion of the removed soil
- Prevention of penetration of rainwater, etc.
- Prevention of outflow of the removed soil and radioactive materials
- Prevention of effects from substances other than radioactive materials
- Resistance to earthquakes, etc.
- Other necessary measures

(2) Management requirements

The four following management requirements are explained.

- Restriction of entry
- Monitoring the radiation dose and carrying out repairs of the facilities
- Keeping records (Table 2-54 lists the items to be recorded)
- Confirmation that the vacant site is not contaminated after the removed soil that had been stored there was taken away

Table 2-54 Items to record pertaining to the storage of removed soil

Category	Items
Basic matters	• Amount of removed soil stored • Dates on which the storage starts for each batch of removed soil stored • Dates on which the storage ends for each batch of removed soil stored • Names and addresses of the receiving sites* • Names and addresses of the destinations of the removed soil after the storage
Information on delivery and receipt	• Names of the persons in charge of delivering the removed soil • Names of the persons in charge of receiving the removed soil • Registration or vehicle number of any trucks • (In case where such trucks were used for the transfer pertaining to the delivery)
Maintenance and control of storage sites	• Details of the measurement, inspection, and testing carried out to maintain and control the place for storage
Measurement of the air dose rate	• Position of the site boundary (fence) and position of the measurement points • Dates measured • Measuring methods • Measuring apparatuses used for the measurements • Measurement results (background and air dose rate along the site boundary) • Name of the inspector
Radioactive concentration of the removed soil, etc.	• Air dose rate on the surface of each container (On the surface of each container with the removed soil, or each group of multiple containers)

2.4.2. Specific Examples of Storage Methods Chosen on the Basis of the Facility/Management Requirements

This section describes two types of relatively small-sized on-site storage facilities both above ground and underground and two types of large-sized on-site storage facilities both above ground and underground in terms of facility specifications and safety management as shown in Table 2-55.

In addition, this section shows two types of both small-sized and large-sized temporary storage sites above ground and two patterns of temporary storage site both underground and on sloped ground in terms of facility specifications and safety management as shown in Table 2-55.

Table 2-55 Examples of storage methods

Storage site	Overground/ underground	Summarized contents of storage site
On-site storage	overground	Mound(2 × 2 × 1m) of removed soil generated during the decontamination of an area whose air dose rate is about 1μSv/hour as as an example of on-site storage over the ground
		Mound (20 × 20 × 1 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1μSv/hour as as an example of on-site storage over the ground
	underground	Pit (2 × 2 × 0.5 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1μSv/hour as as an example of on-site storage under the ground
		Pit (20 × 20 × 1 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1μSv/hour as as an example of on-site storage under the ground
Temporary Storage site	overground	Mound(20 × 20 ×2 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1μSv/hour as as an example of on-site storage under the ground
		Mound (100 × 100 ×2 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1μSv/hour as as an example of on-site storage under the ground
	underground	Pit (50 × 50 × 2 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1μSv/hour as as an example of on-site storage under the ground
	Sloped ground	Mound (20 × 20 × 2 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1μSv/hour as as an example of on-site storage on the sloped ground

Two examples are presented here. The first is a pit (2 × 2 × 0.5 m) containing removed soil produced during the decontamination of an area whose air dose rate is about 1 μSv/hour; it is explained as an example of on-site storage underground. The second is a mound (20 ×20 × 2 m) of removed soil produced during the decontamination of an area whose air dose rate is about 1 μSv/hour; it is explained as an example of a temporary storage site above ground

- Pit (2 × 2 × 0.5 m) of removed soil produced during the decontamination of an area whose air dose rate is about 1 μSv/hour as an example of on-site storage underground (Figure 2-40)

An example of facility specifications and safety management details for the example on-site storage is shown in Table 2-56.

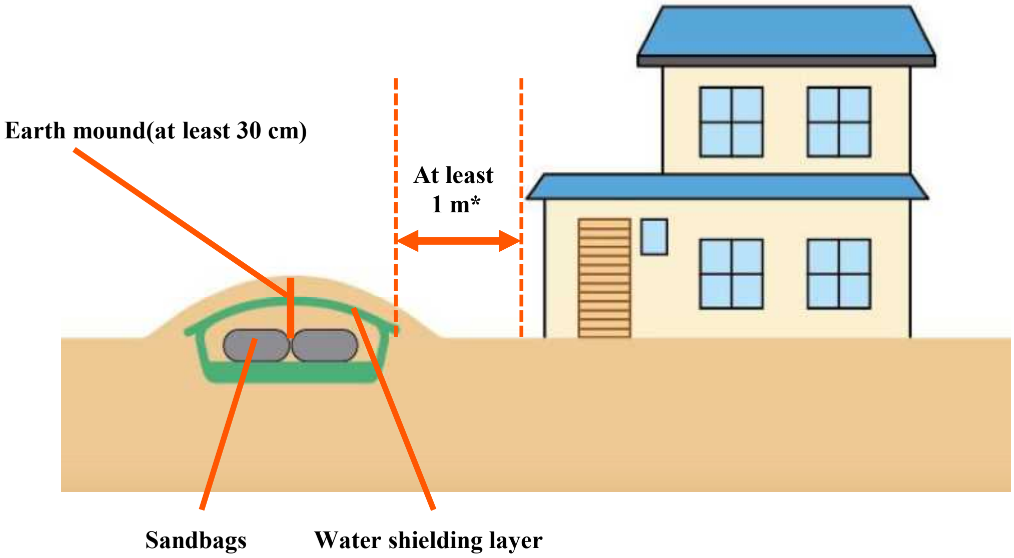


Figure 2-40 Example of on-site storage underground - Pit (2 × 2 × 0.5 m) containing removed soil produced during the decontamination of an area whose air dose rate is about 1 μSv/hour

Table 2-56 Example of facility specifications and safety management details for an underground pit (2 × 2 × 0.5 m) on-site storage of removed soil produced during the decontamination of an area whose air dose rate is about 1μSv/hour

Shielding and isolation	• After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the top or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick. In this case, it is not necessary to maintain an isolation distance from residential buildings, such as private houses. • If the top surface is not shielded, place the removed soil at least 1 m away from residential buildings such as private houses.
Prevention of dispersion	• To prevent any radioactive material from dispersing, put the removed soil in sandbags or flexible containers whose openings can be closed, and close them securely. If the removed soil is not put into any containers such as sandbags, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• Cover the removed soil with a waterproof sheet and fix the ends so that the sheet cannot be blown by the wind as needed. For fixing, sandbags and blocks can be used. • Raise the center to prevent rainwater from accumulating on the surface of the sheet as needed.
Prevention of outflow	• Spread a waterproof sheet over areas where the removed soil is placed. No special measures are necessary if the removed soil is stored in waterproof flexible containers, etc. • When placing the removed soil, take care not to damage the waterproof sheet, etc.
Monitoring	• After completing covering with soil, etc. for the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at the

	center (one spot) and places 1 m apart from four spots on the outer perimeter of the area where the removed soil has been placed and at a height of 1 m (four spots), and record the results. • If it is impossible to conduct such measurements at a place 1m apart from the outer perimeter, select other measurement points. • Record the measurement points by drawing a rough sketch to identify the place of measurement.
Record keeping	• Keep the records of measurement results of the air dose rates until the removed soil is taken out.

- Mound (20 ×20 × 2 m) of removed soil produced during the decontamination of an area whose air dose rate is about 1 μSv/hour as an example of a temporary storage site above ground (See Figure 2-41)

An example of facility specifications and safety management details for an example temporary storage site is shown in Table 2-57.

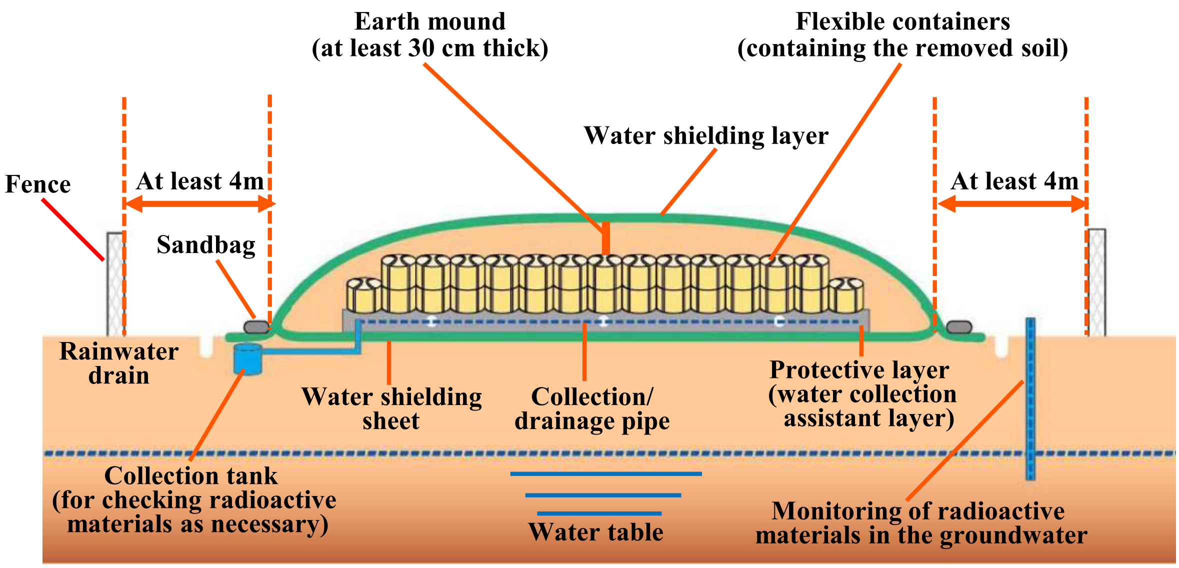


Figure 2-41 Example of temporary storage site above ground – Mound (20 ×20 ×2 m) above ground in temporary storage site of removed soil produced during the decontamination of an area whose air dose rate is about 1 μSv/hour

Table 2-57 Example of facility specifications and safety management details on a mound (20 ×20 ×2 m) above ground in a temporary storage site of removed soil produced during the decontamination of an area whose air dose rate is about 1μSv/hour

Shielding and isolation	• When the delivery work extends over a lengthy period of time, keep the removed soil at least 4 m away from residential buildings such as private houses from the viewpoint of curbing the public's additional exposure dose to not more than 1 mSv per year during the delivery. • During the delivery of the removed soil, shield it by putting flexible containers, etc. containing uncontaminated soil on the side or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick. • After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the top or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick.
Prevention of dispersion	• When delivering removed soil, to prevent any radioactive material from dispersing, put the removed soil into a flexible container, and close it securely. If the removed soil is not put into any containers such as flexible containers, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• During and after the delivery of the removed soil, cover it with a weatherproof and waterproof sheet such as a water shielding sheet to prevent the soil from being exposed to the rain as much as possible. Fix the end of the water shielding sheet so that it cannot be blown by the wind. For fixing, sandbags and blocks can be used. No special measures are necessary if the removed soil is stored in waterproof containers or kept in a facility with a roof. • Raise the center to prevent rainwater from accumulating on the water shielding sheet, etc. • ･Arrange the removed soil so that it is positioned higher than the water shielding sheet, etc. for good drainage. • Install drainage facilities during the delivery to discharge any accumulated rainwater.
Prevention of outflow	• Spread a weatherproof and waterproof sheet such as water shielding sheet over areas where the removed soil is placed. • When placing the removed soil, take care not to damage the waterproof sheet, etc. • Installation of water shielding layer such as laying waterproof sheet can be omitted if the removed soil is stored in waterproof containers and a waterproof cover is properly applied to prevent rainwater from coming in.
Background measurement	Air dose rate • Before the delivery of the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at points along the site boundary and at 1 m height on both sunny and rainy days, and record the results. • The measurement points shall have an interval of about 2 m along the site boundary and include the points on the site boundary nearest to the place of storage of removed soil. • If it is impossible to conduct such measurements at a place 4 m apart from the outer perimeter, select other measurement points. • Record the measurement points by putting a mark on the ground or drawing a rough sketch to identify the place of measurement. • Derive the approximations for the upper limit of variation from the

	measured air dose rate values (at tens of points) and the following equation: $m + 3\times\sqrt{\{(s_1-m)^2+(s_2-m)^2+\cdot\cdot+(s_k-m)^2+\cdot\cdot+(s_N-m)^2\}/N}$ where S1, S2, . . .Sk… SN: Measured values, m: Average of the measured values, and N: Number of the measured values. Radioactivity concentration of the groundwater • Before the delivery of the removed soil, dig a water sampling hole near the planned temporary storage site, sample the groundwater, measure the radiocaesium concentration of the sample, and record the results. • For the installation of the water sampling hole, prevent the intermixing of topsoil and surface water. In addition, implement measures to prevent the intermixing of topsoil and the like as needed. Radioactivity concentration of the leachate (if necessary) • This is not a standard for storage, but if measuring he leachate, install pipes into the protective layer to sample the leachate, and install a collection tank (e.g. working water tank or concrete measuring tank) on the outside of the temporary storage site to collect the sampled leachate. Radioactivity concentration of soil • Before the delivery of the removed soil, sample soil in the planned temporary storage site, measure the radiocaesium concentration of the sample, and record the results. • The measurement points shall be at the center and four corners of the area in which removed soil is placed.
Monitoring	Air dose rate • After the delivery of the removed soil starts, use a calibrated scintillation survey meter, to measure the air dose rate at a height of 1 m at four spots including a spot nearest to the place of storage of removed soil among the background measurement points, and record the results. • Take such measurements at least once a week. Radioactivity concentration of the groundwater • After the delivery of the removed soil starts, sample the groundwater from the sampling hole, measure the radiocaesium concentration of the sample, and record the results. • Samples of the groundwater should be taken when there is no turbidity. • Take such measurements at least once a month. Radioactivity concentration of the leachate (if necessary) • After the delivery of the removed soil starts, check whether water is accumulated in the collection tank at least once a month. • If water has accumulated, sample the leachate and measure the concentration of radiocaesium, etc. in the sampled leachate.
Record keeping	• Keep the following records until the period of operation of the facility ends. • The amount of the removed soil stored, dates on which the storage starts and ends for each batch of the removed soil stored, and the names and addresses of the receiving site and destinations of the removed soil after the storage. • The names of the persons in charge of receiving and delivering the removed soil concerning such removed soil received, and the registration or vehicle number of any truck in case where such truck was used for the transfer pertaining to the delivery. • The results of an air dose rate measurement and water quality test (measurement of the radioactivity concentration of groundwater).

Repair	• Confirm that the measured values of the air dose rate and the radiocaesium concentration of the groundwater are within the allowable variation range of the background values. (Note that during the delivery of the removed soil, the measured air dose rate shall not exceed the allowable variation range plus air dose rate equivalent to 1 mSv/year.) • If the measured value is observed to be exceeding the allowable variance range, etc., identify the cause. If it is found that the temporary storage site2 is the cause of such problem, take any necessary measures, such as adding shielding materials, repairing the facility, or collecting the removed soil.
Restriction of entry	• Construct fences (e.g. ropes, nets, or iron wire) at the periphery of the area at least 4 m away from the temporary storage site. • Install signboards at least 60 cm × 60 cm in visually obvious places to indicate precaution to the effect that the area is the place of storage of the removed soil, the contact details in the event of an emergency, and the height of the piled-up removed soil.
Vacant site check	• After the period of storage ends and the removed soil is taken out of the temporary storage site, measure the Cs-134 and Cs-137 concentration of soil at the vacant site and confirm that the resulting values are within the variation range of the background concentration. • The measurement points shall be at the center and four corners of the area in which removed soil had been placed. • If the measured value is observed to be exceeding the allowable variation range, decontaminate the site.

3. Management and treatment of decontamination wastes

3.1. Temporary Storage Sites and Final Disposal

3.1.1. Waste Treatment Flow and Necessity of Temporary Storage Sites

As shown in Chapter 1, the “Urgent Implementation Basic Policy on Decontamination” (“Urgent Implimentation Policy” in this document) (announced on August 26, 2011 by the Nuclear Emergency Response Headquarters (NERH); hereafter referred to as the “Basic Policy on Decontamination”) prescribes that, concerning the following description about the disposal of wastes and soil contaminated by radioactive materials: “The National Government shall be responsible for securing disposal sites that require long-term management as well as safety of such sites, and will create and announce a roadmap to construct such sites as quickly as possible.”

On the other hand, the Basic Policy on Decontamination also states: “Time is needed to secure and prepare disposal sites that require long-term management. Decontamination might not proceed quickly if such disposal sites must be put in place first.” The Basic Policy on Decontamination stresses the needs of temporary storage sites as: “It is realistic that such temporary storage site(s) is (are) to be located ineach municipality or community has its own individual temporary storage site(s) for the time being to keep soil and wastes produced by decontamination.”

In response the MOE on October 29, 2011,presented its basic philosophy “Basic Philosophy on Interim Storage and Other Facilities Required for the Handling of the Environmental Pollution from Radioactive Materials Associated with the Accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company” (hereafter referred to as the “MOE Basic Philosophy on Interim Storage”),

The MOE Basic Philosophy on Interim Storage is summarized in Figures 3-1 to 3-3, and includes the flow schematics for treatment of wastes and the roadmap towards the installation of an interim storage facility in Fukushima Prefecture, where significant amounts of removed soil and other wastes are anticipated to be produced.

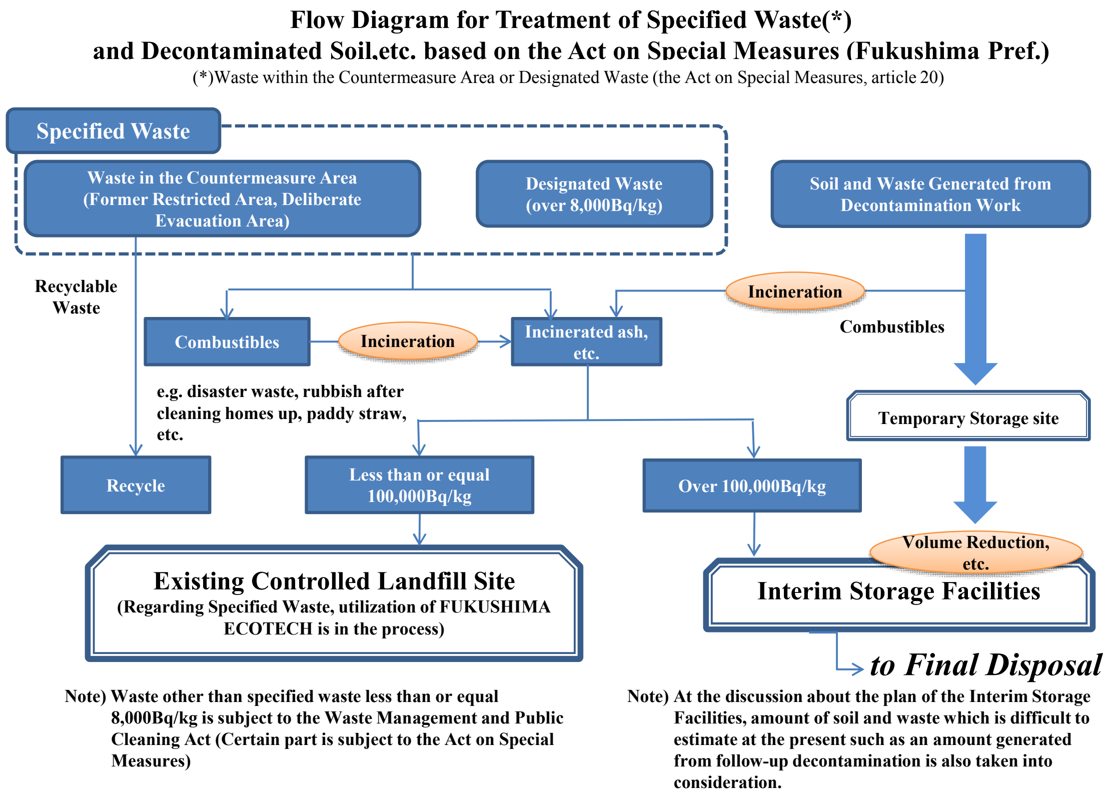


Figure 3-1 Treatment flow of specified and other wastes produced in decontamination (Fukushima Prefecture)[80].

[80]Source: Ministry of the Environment (MOE), “Basic Philosophy on Interim Storage and Other Facilities

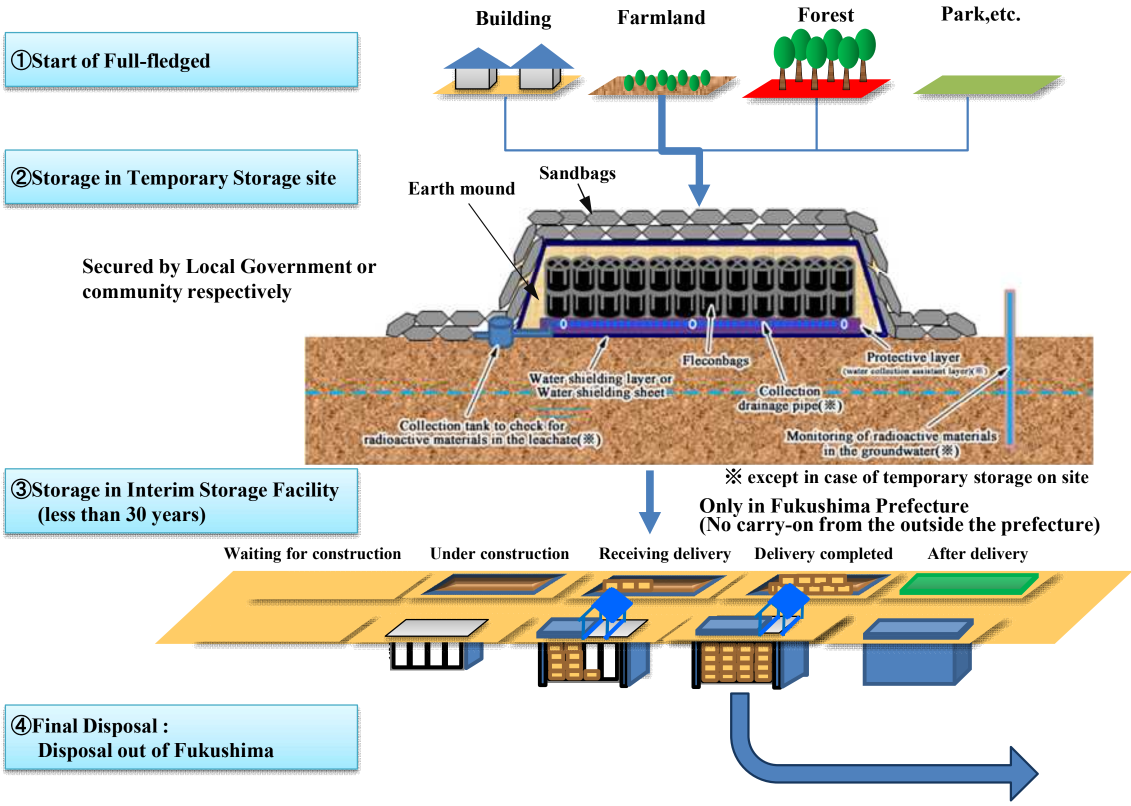


Figure 3-2 Treatment of soil and wastes produced in decontamination (Fukushima Prefecture).

Required for the Handling of the Environmental Pollution from Radioactive Materials Associated with the Accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company" (October 29, 2011). Figure 3-3 and Figure 3-3 are generated from the same source.

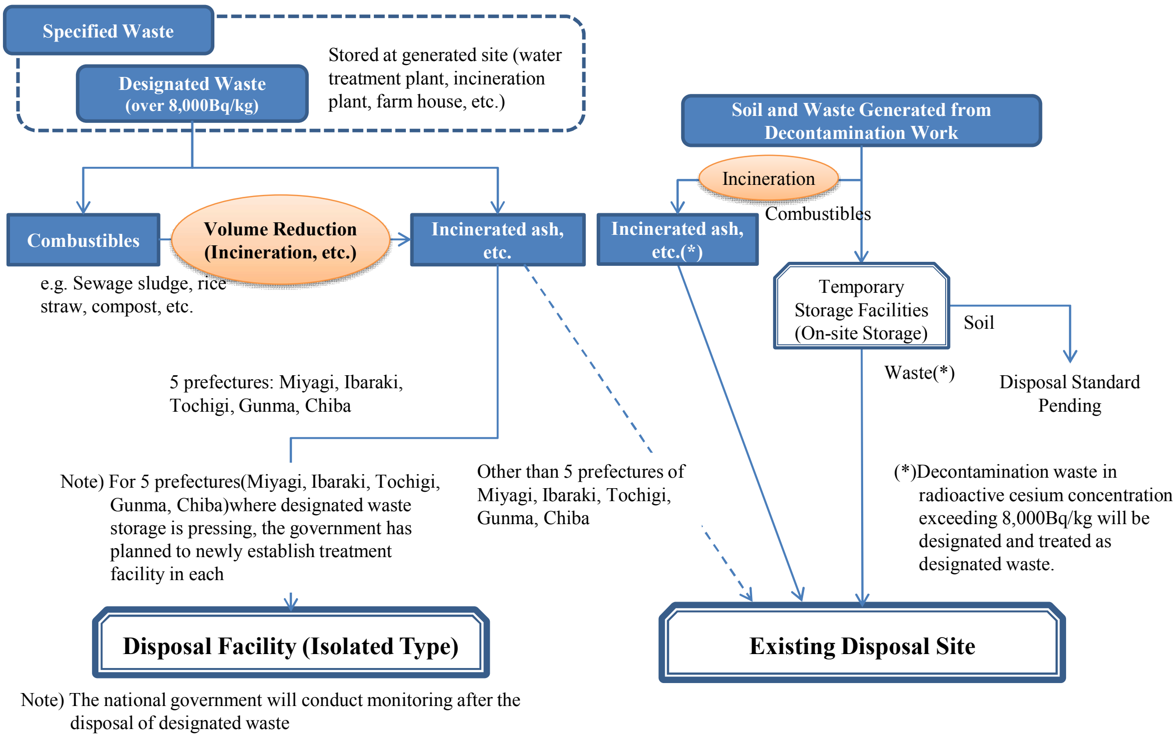


Figure 3-3 Treatment flow of specified and other wastes produced in decontamination (areas outside Fukushima Prefecture).

3.1.2. Configurations of Temporary Storage Sites

Facility configurations, their management, and other conditions necessary for temporary storage sites to quickly begin decontamination work are specified in the “Guidelines Pertaining to the Storage of Removed Soil” as shown in Chapter 2.4 of this Decontamination Report (the “report” in this document).

However, most of the descriptions in the Guidelines are relevant to the prevention of effects from radioactive materials on human health and the living environment. In the installation of a temporary site, there are other conditions required, too, such as fire prevention measures.

Basic configurations of temporary storage sites are shown below in more detail, using the classifications for the wastes to be stored in the temporary storage sites.

(1) Storage of combustibles

Combustibles such as naturally fallen leaves and branches, and intentionally cut branches, etc. generate gases by their decomposition and when accumulated, that might lead to a fire. Therefore, they should be covered with gas- and air-permeable waterproof sheets or the like and gas venting pipes should be provided. Storage conditions of wastes should be checked regularly, and if white smoke or steam, etc. is noticed, appropriate management measures should be taken by, for instance, measuring the interior temperatures of the accumulated wastes (Figure 3-4).

(2) Storage of non-combustibles like soil

Non-combustibles like removed soil may be stored after being covered with waterproof (seepage control) sheets, since they do not generate gases during storage (Figure 3-5).

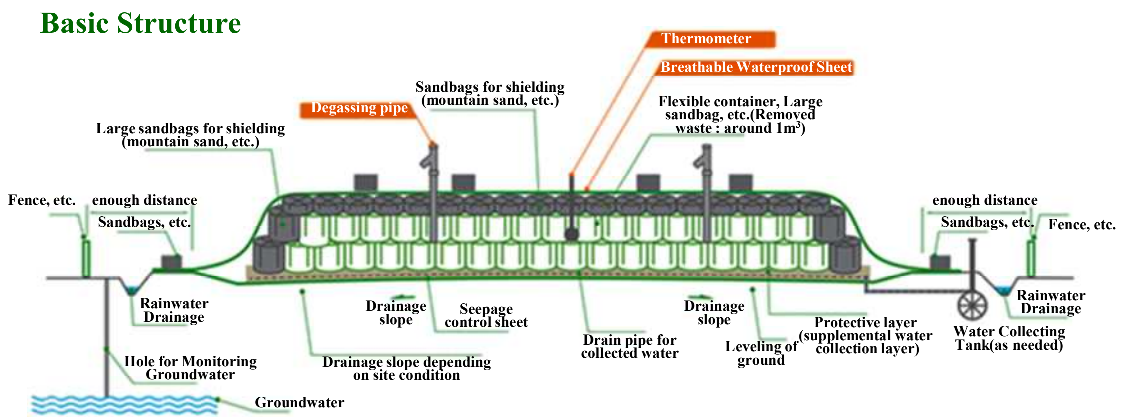


Figure 3-4 Basic configuration of a temporary storage site above ground for combustibles removed in decontamination work[81].

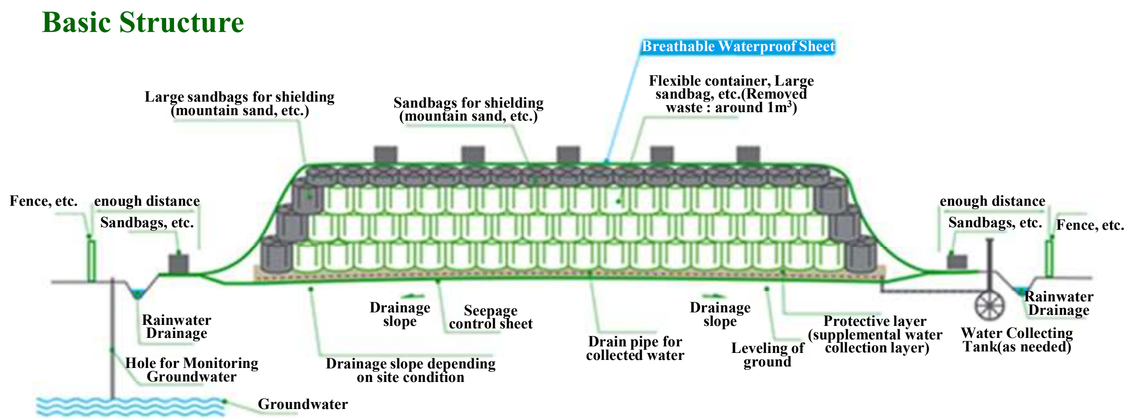


Figure 3-5 Basic configuration of a temporary storage site above ground for non-combustibles removed in decontamination work.

[81]Source: Decontamination Information Site (http://josen.env.go.jp/soil/temporary_place.html). Figure 3-5 has the same source.

3.1.3. Examples of Temporary Storage Sites

Some examples of temporary storage sites cited from the "Temporary Storage Site Installation Casebook" (August, 2013), which was compiled by the Division of Fukushima Prefecture Decontamination Measures, are presented here.

As given in Table 3-1, the above-mentioned document gives ten examples of temporary storage sites, two examples of air dose rate measurements, and an example of a field observation tour to a temporary storage site.

Figures 3-6 to 3-10 show examples of temporary storage sites located in a swimming pool, a forest, an abandoned quarry, the vicinity of a condominium, and a dry field.

Table 3-1 Examples collected in the "Temporary Storage Sites Casebook"[82]

Content	Example
Examples of installation	i) Public facility (Pool) (Koori town) ii) Paddy field (Yugawa village) iii) Plowed field (Kawamata town, Ten-ei village) iv) Forest (Miharu town, Tamakawa village) v) Residents area neighborhood (Koori town, Date city) vi) Land adjacent to paddy field and orchard (Date city) vii) Utilization of mountain sand collection place ruins (Date city)
Measurement of air dose rate	i) Housing development neighborhood (Koori town) ii) Plowed field (Kawamata town)
Field inspection party of temporary storage site	Field inspection party of temporary storage site for Ono town inhabitants (Kawamata town)

[82] Source: Division of Fukushima Prefecture Decontamination Measures, "Temporary Storage Site Installation Examples" (August, 2013). (Figure 3-6 to Figure 3-10 are generated from the same source.)

(1)　A temporary storage site using a swimming pool

【 Before installation 】

【 After installation 】

Area, etc.	Approx. 2,500m² (municipal ownership place)
Waste to be delivered	Removed soil and vegetation generated by decontamination of educational facilities
Form of facility Storage Capacity	Semi-underground facility Approx. 1,100m³ (using weather resistance large sandbags)
Status of management	○Air dose rate (measuring daily (week day)) [before delivery] 0.47μSv/h(2012.5) [after delivery] 0.28μSv/h(2013.7) ○Radioactivity concentration of the groundwater (measuring weekly) [Before delivery] N.D.(2012.5) [After delivery] N.D.(2013.7) ○Radioactivity concentration of the leachate (measuring when the leachate is discovered)
Location of installation	The facility has been installed with the public pool which was not used in an earthquake disaster. It is approx. 30 meters to the most recent residential house.

Figure3-6 A temporary storage site using a swimming pool.

(2)　A temporary storage site in a forest

【 Before installation 】

【 After installation 】

Area, etc.	4,683m² (national forest)
Wastes to be delivered	Removed soil and fallen leaves generated by decontamination of school and school route, etc.
Form of Facility Storage Capacity	Above ground facility Approx. 1,788m³ (using flexible container)
Status of management	○Air dose rate (measuring weekly) [Before delivery] 0.26μSv/h(2012.11) [After delivery] 0.14μSv/h(2013.5) ○Radioactivity concentration of the groundwater (measuring monthly) [Before delivery] N.D.(2013.5) [After delivery] N.D.(2013.6) ○Radioactivity concentration of the leachate (measuring when the leachate is discovered)
Location of installation	The national forest has been developed for the installation of temporary storage site. A swamp flows near. (approx. 10 meters to the swamp) It is approximately 500 meters to the most recent residential house.

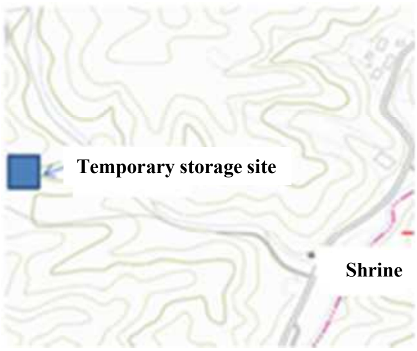


Figure 3-7 A temporary storage site in a forest.

（3） A temporary storage site in an abandoned place digging out sand in a mountain

【 Before installation 】

【 After installation 】

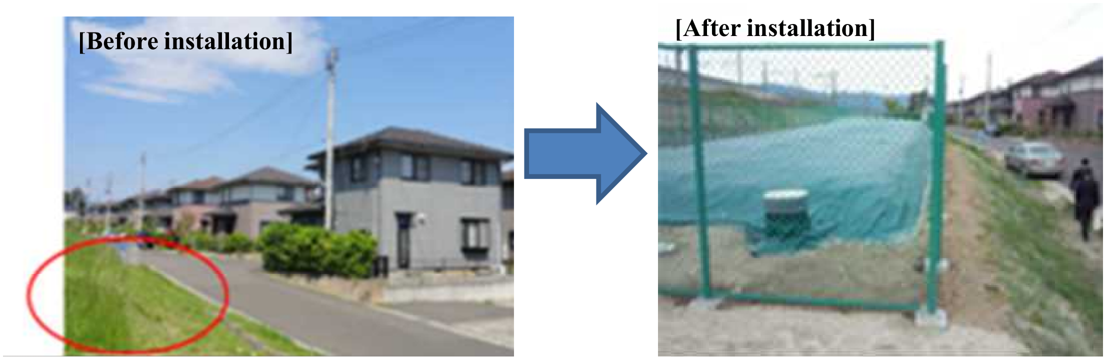
Area, etc.	9,894m² (private land)
Wastes to be delivered	Removed soil and vegetation generated by decontamination of residential houses and roads
Form of Facility Storage Capacity	Above ground facility 3,303m³ Breakdown : Combustibles:552m³ Incombustibles:2,751m³(using flexible container)(city ordering)
Status of management	○Air dose rate (measuring weekly) [Before delivery] 0.33μSv/h(2013.1) [After delivery] 0.57μSv/h(2013.8) ○Radioactivity concentration of on-site pond water (measuring monthly) [Before delivery] N.D.(2012.12) [After delivery] N.D.(2013.8) ○Radioactivity concentration of the leachate (measuring when the leachate is discovered)

【 Temporary storage site inside 】

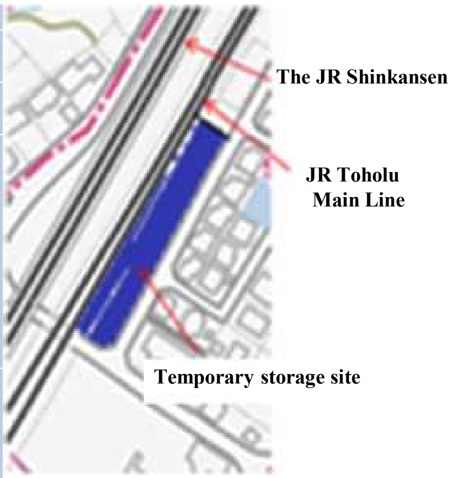
Figure 3-8 A temporary storage site in an abandoned place digging out sand in a mountain.

（4） A temporary storage site near a residential area

⑤-1 Residents Area Neighborhood (Koori town)



Area, etc.	Approx. 900m² (Municipal ownership place)
Wastes to be delivered	Removed soil and vegetation generated by decontamination of residential house
Form of Facility	Semi-underground facility
Storage Capacity	750m³ (using flexible container)
Status of management	○Air dose rate (measuring daily (week day)) [Before delivery] 0.62μSv/h(2012.11) [After delivery] 0.26μSv/h(2013.6) ○Radioactivity concentration of the groundwater (measuring monthly) [Before delivery] N.D.(2012.11) [After delivery] N.D.(2013.6) ○Radioactivity concentration of the leachate (measuring when the leachate is discovered)
Location of installation	The temporary storage site has been installed using Green belt between residential area and railway(Tohoku Main Line) . It is approximately 10 meters to the most recent residential house.



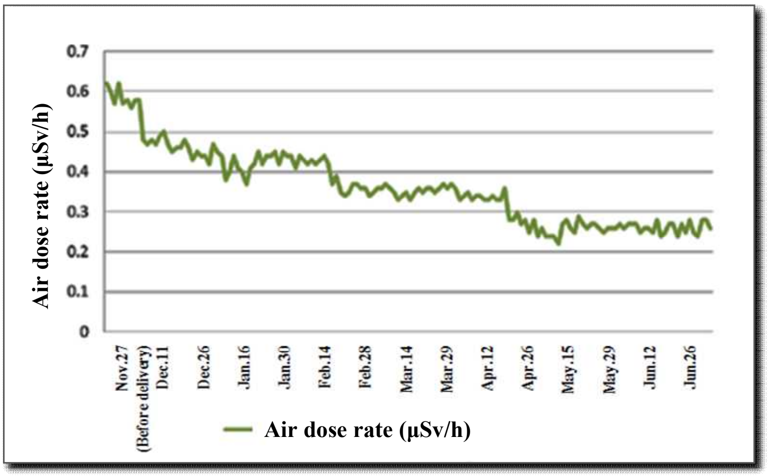


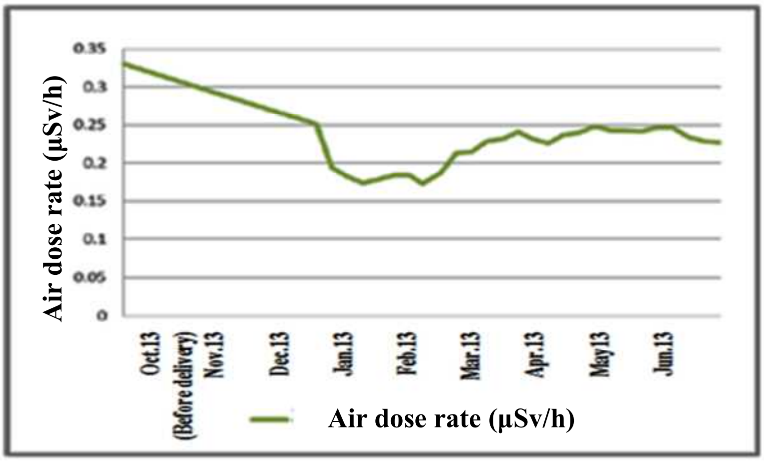
Figure 3-9 A temporary storage site in the vicinity of a condominium.

（5） A temporary storage site in a dry field

[Before installation]

[After installation]

Area, etc.	20,331m^2 (private land)
Wastes to be delivered	Removed soil,etc. generated by decontamination of residential house and road,etc.
Form of Facility Storage Capacity	Above ground facility Approx. 5,350m^3 (using weather resistance large sandbags)
Status of management	○Air dose rate (measuring weekly) [Before delivered] 0.33μSv/h(2012.10) [After delivered] 0.25μSv/h(2013.6) ○Radioactivity concentration of the swamp water (measuring monthly) [After delivered] N.D.(2013.6) * Because water level under the ground is low and specimen can not be gathered, the swamp water is measured. ○Radioactivity concentration of the leachate (measuring when the leachate is discovered)
Location of installation	Mulberry field has been developed for the installation of temporary storage site. It is approximately 200 meters to the most recent residential house.



* Measuring air dose rate at the plural points in the temporary storage site
* Reason why the air dose rate decreased during January to March is considered to be the effect of shielding by snow.

Figure 3-10 A temporary storage site in a dry field.

3.2. Wastewater Treatment

3.2.1. Notes of Caution for Wastewater Treatment

Water is used in high-pressure water cleaning of roofs, roads and the like for decontamination as well as possibly in the cleaning of tools used for decontamination.

Wastewater used in these tasks must be treated appropriately, as it might have been contaminated by radioactive materials. However, most radioactive cesium is in a form that is strongly adsorbed on soil particles, and hardly any of it will dissolve into the wastewater. Therefore, the central element of wastewater treatment is to remove fine soil particles contained in the wastewater.

（1） Necessity of wastewater collection and treatment

The "Guidelines Pertaining to Decontamination and Other Measures," mentioned in Chapter 2.2 of this report specifies that no wastewater treatment is essentially needed in cases where soil sediments are removed in the decontamination work in decontamination areas (areas subject to the decontamination plans established by relevant municipalities).

However, in principle, wastewater should be treated in situations where the wastewater is highly turbid or the wastewater has been collected from high-pressure water washing with vacuum collection of water.

（2） Notes of caution for decontamination of water used for washing

When decontaminating using water, the sequence of decontamination should be determined as shown below with consideration of water transfer (Chapter 2.2). The wastewater discharge channels should be checked, the wastewater flow should be dammed up using sandbags and the like as needed to allow fine soil particles contained in it to settle and be collected. Then the supernatant liquid may be discharged (Figure 3-11). Actual scenes and methods of wastewater treatment are shown in Figure 3-12 and Figure 3-13. Figure 3-14 shows an example of high-pressure water cleaning equipment with vacuum collection of water.

In Fukushima City and other municipalities, there have been examples of formulating decontamination plans, as seen in Figure 3-15, in consideration of local rainwater and surface water flows, when planning the decontamination works..

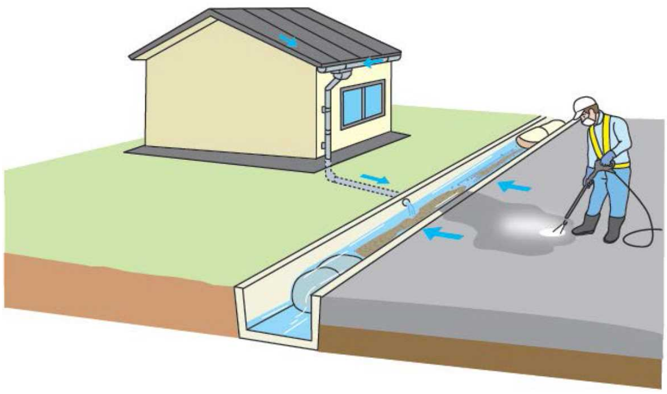


Figure 3-11 Treatment of wastewater used in washing (including sedimentation already present in the street drains)[83].

[83]Source: Ministry of the Environment (MOE) "Guidelines pertaining to decontamination and other measures" (2nd Edition (amended in December 2014)), http://josen.env.go.jp/material/pdf/josen-gl02_ver2_supplement1412.pdf),

Figure 3-12　Treatment of wastewater used in washing (Kawauchi Village)[84]

8. Treatment of wastewater from cleaning

Cleaning is essential in the house decontamination, but it is difficult to recover all the wastewater. The measures such as follows are taken on the site.

①Minimizing use of water with water for the last finish, in advance removing moss, soil, and the like with radioactive materials by hand which deposit on roof, rainwater guttering, etc., then absolutely decreasing migration of radioactive materials into cleaning water.

(The past 19 times measurement results of wastewater from cleaning: approx. 36Bq/l on average)

②Reducing a outflow of radioactive materials to lower basin by installing "filtering device" using zeolite in street drains to which wastewater is channeled. However, this method requires the establishment of storage area like temporary storage site, etc. for sedimented soil and spent zeolite.

(The past 19 times measurement results of wastewater from cleaning: approx. 10Bq/l on average after filtration, resulting in average reduction rate of 73%)

<Example of "Filtering Device" using street drains>

- **Because radioactive cesium is almost adhered to soil, "Filtering Device" as shown in the rough sketch below shall be installed so that muddy water in wastewater does not flow out to lower basin, sedimented soil.**
- **Very small amount of radioactive cesium contained in supernatant liquid shall be adsorbed to zeolite, etc.**

Example of construction

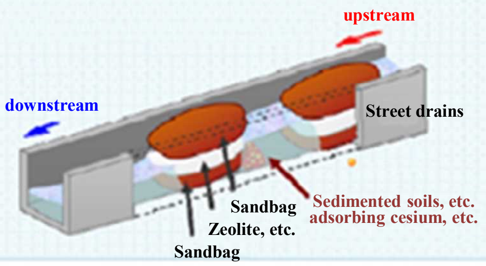


Figure 3-13　Treatment of wastewater used in washing (Fukushima Prefecture)[85].

[84]Source: Kawauchi Village (October 1, 2013), Decontamination and dose control for villagers to return from full evacuation

[85]Source: Fukushima City (January 2013), Decontamination status in Fukushima City, Fukushima City (January 2013)

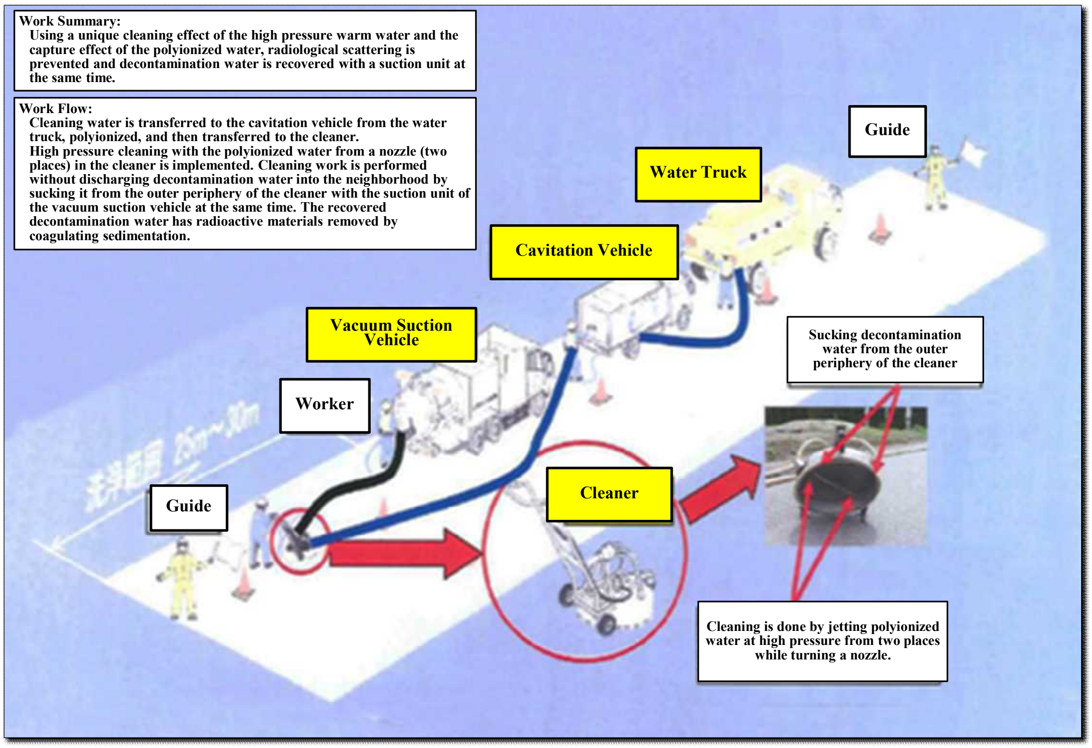


Figure 3-14 Decontamination of roads by high-pressure washing with vacuum collection of the water used (Kawauchi Village)[86].

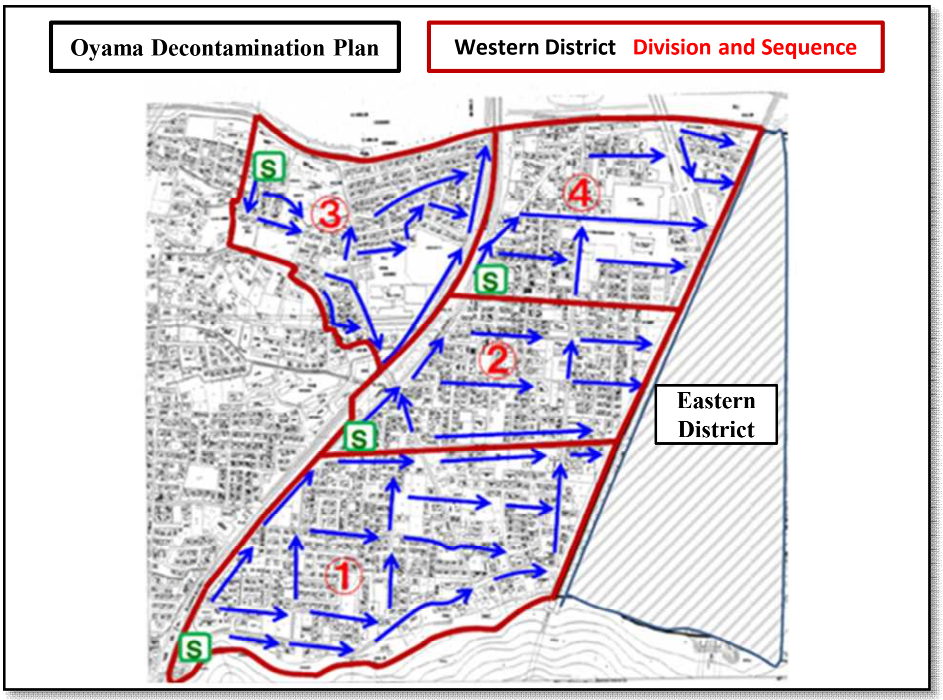


Figure 3-15 Decontamination plan taking water channels into account (Arrows indicate water flow lines)[87].

[86]Source: Kawauchi Village (October 1, 2013), Decontamination and dose control for villagers to return from full evacuation

[87]Source: Fukushima City (January 2013), Decontamination status in Fukushima City

3.3. Volume Reduction

3.3.1. Necessity of Volume Reduction

Wastes contaminated with radioactive materials and secondary wastes from decontamination works are produced in large quantities. Therefore, volume reduction is essential in the process of treatment and disposal of those wastes, in order to reduce the total amount of waste produced and to secure the storage sites. Combustible wastes contaminated with radioactive materials need to be stabilized to prevent their decomposition and emission of unpleasant odors. Intermediate treatment by incineration and other means can reduce the disposal volume to around one-twentieth to one-fifth of the original volume.

3.3.2. Volume Reduction Methods

There are many volume reduction methods from physical processes such as simple compression and crushing to chemical processes such as incineration and melting. Characteristics of each method are summarized in Table 3.2.

Table 3-2 Comparison of volume reduction methods[88]

Method	Volume reduction effect	Decontamination effect	Workability	Volume reduction rate (%)	Measures	Secondary waste
Melting	○	○	△	～99	Effluent gas	much
High Temperature Incineration	○	○	△	～90	Effluent gas	much
Low Temperature Incineration	○	△	○	50～80	Effluent gas	little
Drying	△	×	○	5～30	---	none
Cleaning	△	△	○	5～10	Wastewater	much
Classification	○	△	△	10～90	Wastewater	little
Compression	△	×	○	20～50	---	none
Shredding	△	×	△	～50	Dust	little

Each method of volume reduction is outlined below, being cited from the "Report on the surveys of off-site emergency responses associated with the accident at the Fukushima Daiichi Nuclear Power Station and the environmental restoration activities[88]."

（1） Melting method

The melting method reduces the volume of solid wastes by elevating their temperatures by means of plasma heating and other means up to super high temperatures (above 1,200 °C) and produces stable molten slag, while achieving a high decontamination effect by volatilizing most of the cesium including radioactive cesium(hereinafter referred to as "cesium") present. But, while the melting method volatilizes even silicic acids and other substances, treatment of a large quantity of secondary gaseous wastes becomes

[88]Source: Atomic Energy Society of Japan (December 2, 2013), Report on the surveys of off-site emergency responses associated with the accident at the Fukushima Daiichi Nuclear Power Station and the environmental restoration activities. (Table 3-3 has the same source.)

necessary. It is not practical to apply this method to the treatment of large quantities of contaminated wastes, in view of the work conditions at super high temperatures and the cost of fuel to melt the wastes.

（2） High temperature incineration

The high temperature incineration method reduces the volume of contaminated wastes by burning them (using heavy oil and other fuel) at temperatures up to around 1,000 °C in the air, volatilizing contained water and volatile oxides. Cesium volatilization is limited, but some cesium could be scattered and contaminate the upper part of incinerator or other parts depending on combustion temperatures and conditions. This method is well established and is able to treat massive wastes.

（3） Low temperature incineration

The low temperature incineration method burns wood and other materials in a reducing atmosphere of 600 to 800 °C, and then carbonizes the cinders for volume reduction. By volatizing carbon and hydrogen contents in the wastes, the volume reduction rate reaches around 90%, and no secondary wastes are produced because cesium volatilization is restrained. But, on the other hand, the cesium concentration in the residue becomes higher. This makes it necessary to give special consideration to the handling and storage methods depending on the concentrations of radioactive materials when radioactivity exceeds 8,000 Bq/kg, although the volume of wastes to be handled is decreased.

（4） Drying

Drying is carried out by heating wastes at the ambient temperature or below 100 °C. Big weight and volume reductions are achieved in the case of watery sludge. Trees and vegetation materials can be reduced in volume by drying to some extent, and no further secondary treatment is needed regarding decomposition and other undesirable changes.

（5） Washing

The washing method aims at reducing the volume of contaminated wastes by: dissolving the soluble materials by high-pressure water washing or immersing into water; separating fine particles from larger solids by suspending the fine particles in the water; and collecting the solids by solid/liquid separation such as filtration or other means. In this method radioactive cesium is dissolved into water and fine particles with adsorbed cesium are separated. The target objects can be decontaminated, but the water content of the waste collected is high and a secondary treatment is needed for volume reduction by drying and other means. Furthermore, the liquid collected contains a high concentration of cesium and also needs a secondary treatment for sorption and separation of the cesium.

（6） Classification

Classification is a method to separate and fractionate fine particles such as clay, to which cesium adheres, by sieves, and to reduce the volume of contaminated soil. There are two types of classification methods: the wet method uses a difference in sedimentation order in the water and the dry method uses sieving. The wet method gives effective separation, but the amount of secondary waste such as contaminated water increases. In contrast, the dry method is advantageous in producing no secondary waste, although it is a rough separation process. If a predetermined radioactivity decontamination effect is obtained in the separation by the particle size, the dry method is effective as a pretreatment method.

（7） Compression

The compression method is a method to reduce the volume by compressing contaminated wastes having low bulk densities with a press machine and other means. Because none of the radioactive materials are transferred, after being processed the wastes contain a higher density of radioactivity per unit volume. Therefore, it becomes necessary to give consideration to the handling and storage methods. This method is effective for application to contaminated wastes such as wood, trees and plant materials.

(8) Crushing

The crushing method is applied to contaminated wastes having shapes of a rectangle, circle or the like. The size of such contaminated wastes is reduced by crushing and densification, and thus the space for waste storage is reduced. No decontamination effect is obtained, since radioactive materials are not transferred by the crushing method. It is necessary to be careful not to disperse fine particles when crushing.

It should be noted that there are diverse wastes produced by radioactive contamination, and by decontamination, too. Therefore, suitability of individual methods of volume reduction depends on the target wastes for application. As shown in Table 3-3, there are cases in which sufficient effects cannot be obtained in volume reduction.

Table 3-3 Applicability of volume reduction methods for selected target items

Object	Volume reduction method	Weight loss	Cesium movement	Radioactivity	Volume reduction effect
Soil	Melting	yes	yes	decrease	large
	Incineration	yes	no	increase	large
	Cleaning	yes	yes	decrease	small
	Classification	yes	yes	decrease	medium
Wood	Incineration	yes	no	increase	large
	Low Temp. Incineration	yes	no	increase	medium
	Cleaning	yes	yes	decrease	small
	Compression	no	no	almost same	medium
Grass, Rice straw	Incineration	yes	no	increase	large
	Low Temp. Combustion	yes	no	increase	medium
	Cleaning	yes	yes	decrease	small
	Compression	no	no	increase	large
Concrete	Compression	no	no	almost same	small
	Shredding	no	no	almost same	medium
Sludge	Drying	yes	no	increase	medium
	Cleaning	yes	yes	decrease	small

3.3.3. Examples of Volume Reduction

A few examples of ongoing volume reduction activities of wastes are shown below.

(1) Crushing

Cut branches produced from the forest decontamination are bulky and need much space if they are packed as they are and they produce many waste containers. Therefore, a crushing facility can be used to crush cut branches for more effective packing in flexible containers. An example is practiced in Katsurao Village and other municipalities.

Figure 3-16 Branches cut down (left) in forest decontamination and a crushing facility (right)[89].

Figure 3-17 Interior views of a crushing facility: collection (left), putting in and crushing (center), and packing into flexible containers (right).

(2) Chipping

The volume of contaminated wastes produced from decontamination work, such as branches and leaves, can be reduced by crushing into chips. Then, they can be stored more effectively in the temporary storage site of limited space. This method is being practiced in Date City and other municipalities.

[89]Source: Okumura-gumi Corporation (Figure 3-17 has the same source.)

Figure 3-18　Before (left) and after (right) chipping[90].

Figure 3-19　Chipping machine.

(3)　Compression / Packaging

Examples (1) and (2) above are intended to reduce the volume of wastes by crushing so that the materials become more tightly packed. There is another example of volume reduction by suction compression as shown below.

In this example, the volume is reduced by suction compression using compression storage bags. If ordinary packing bags are used, the suction openings tend to become clogged with leaves or the bags become torn by branches, but these difficulties can be overcome by using a special nozzle and a special compression storage bag, enabling the volume to be reduced to 1/3 to 1/2 of the original volume for combustibles such as fallen leaves, branches with leaves, grasses, etc.

The compression storage bags have an added odor killing function that controls odors from the combustibles arising around the temporary storage sites.

[90] Source: Division of Fukushima Prefecture Decontamination Measures (May 17, 2013), Decontamination Good Practices Casebook (Figure 3-19 has the same source.)

Figure 3-20 Before (left) and after (right) compression[91].

[91]Source: Taisei Corporation homepage
(http://www.taisei.co.jp/about_us/release/2013/1353289519671.html)

4. Management of decontamination projects

4.1. Flow of the Decontamination Process

The basic flow of the decontamination process is shown in Figure 4-1.

Targets for decontamination extend over a wide range, including soil, houses, roads, fields and forests (only within living spaces). Decontamination was first focused on buildings and residential areas necessary for the protection of human health. Therefore, the first thing to do was to investigate ownership of land plots and buildings.

The next things to do were to measure radiation dose and to survey the state of buildings and other structures in advance of the decontamination work, because the attachment conditions of radioactive substances differ depending on the material to which they are attached. Based on the investigation results, decontamination plans were prepared for each land plot and building that would ensure the most effective methods would be used.

The decontamination work was moved forward by getting the understanding of land and building owners for field surveys, their confirmation of decontamination methods, and finally their consent for conducting the decontamination work. More specifically, their consent to enter the land was obtained, the decontamination plans were explained (to obtain the consent to conduct the decontamination work and to report on commencement), and the results of the decontamination work and other related things were reported.

After the completion of the decontamination work, the effectiveness of the decontamination was checked, and this monitoring was continued to check that the radiation dose has been sufficiently reduced allowing the residents to return.

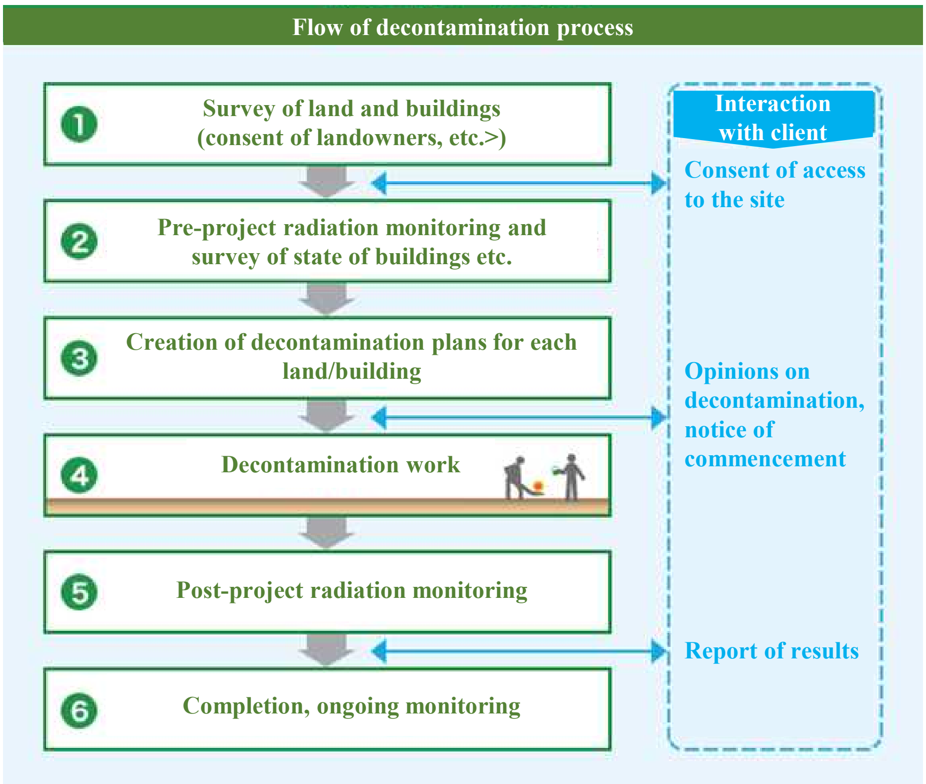


Figure 4-1 Flow of decontamination process[92].

[92]Source: Decontamination Information(http://josen.env.go.jp/about/method_necessity/method_area.html)

4.2. Contents of Decontamination Work

This section describes the specific contents actually implemented by the Ministry of the Environment (MOE) and decontamination business operators for decontamination and related works in the Special Decontamination Areas as ordered by the MOE.

(1) Knowing the air dose rates by detailed monitoring

(2) Issuing of decontamination work orders and related matters by the ordering party (MOE)

(3) Implementing decontamination work by decontamination business operators

(4) Securing necessary resources by decontamination business operators

4.2.1. Knowing the Air Dose Rates by Detailed Monitoring

The MOE carried out extensive monitoring between November 2011 and April 2012 in order to produce detailed air dose rate distribution charts and to prepare for formulating decontamination plans focusing on residential areas in the area that were subject to decontamination work by the national government (Special Decontamination Areas) under the Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District Off the Pacific Ocean Earthquake That Occurred on 11 March, 2011 ("Act on Special Measures" in this report).

(1) Summary of implementation

The monitoring program was implemented under the direction and supervision of the MOE. The monitoring was carried out by the Japan Atomic Energy Agency (JAEA) mobile monitoring vehicles and drone helicopters, and by Tokyo Electric Power Co., Inc. (TEPCO) employees making hand-carry measurements over a 100 m grid as well as using mobile monitoring vehicles (TEPCO cooperated at the request of the MOE on these extensive monitoring activities), in the restricted area and the deliberate evacuation area where the air dose rates were 20 mSv and 50 mSv per year, respectively, as well as areas where the air dose rates were lower (1 mSv, 5 mSv and 10 mSv per year).

More specifically, based on the monitoring data in the restricted area and deliberate evacuation areas published by the Cabinet Office and the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the areas for detailed monitoring were selected on a 2 km x 2 km grid in each area corresponding to respective radiation dose ranges. Consideration was given to the distribution of residential areas in determining the extent of areas for detailed monitoring. Each section of 2 km x 2 km was then in principle zoned in a 100 m meshed grid, in order to gain a more extensive understanding of the air dose rate distribution.

Eleven municipalities were monitored: Tamura City, Minamisoma City, Kawamata Town, Naraha Town, Tomioka Town, Kawauchi Village, Okuma Town, Futaba City, Namie Town, Katsurao Village and Iitate Village.

Table 4-1 Summary of detailed monitoring[93]

Area	Implementation period	Method
Neighboring region of 50mSv per year	Dec. 15, 2011 to Dec. 21 Jan. 6, 2012 to Jan. 16	Monitoring by monitoring car and measuring personnel
Neighboring region of 20mSv per year	Nov. 7, 2011 to Nov. 24	Monitoring by monitoring car and monitoring personnel
Neighboring region of 10mSv per year	Feb. 17, 2012 to Feb. 28 Apr. 6, 2012 to Apr. 12	Monitoring by monitoring car and monitoring personnel
Neighboring region of 5mSv per year	Jan. 6, 2012 to Mar. 3	Monitoring by unmanned helicopter
Neighboring region of 1mSv per year	Feb. 17, 2012 to Feb. 28	Monitoring by monitoring car

（2） Measurement methods

In order to efficiently understand the radiation data at each point of the 100 m mesh grid, while using existing data, additional data were collected by monitoring vehicles (measurement instruments were mounted on cars), aerial monitoring (measurement instruments were mounted on drone helicopters) and persons walking through areas with hand-carry instruments.

The basic policy followed in selecting monitoring methods was to use mobile monitoring vehicles for the urban and residential areas and suburban roads, and to use drone helicopters or rely on persons walking for schools, parks and fields with no roads.

（3） Results of detailed monitoring

Detailed monitoring clarified the distributions of air dose rates, mainly in residential areas, and they were classified into three ranges: below 20 mSv per year (3.8 μSv/h), between 20 and 50 mSv per year (9.5 μSv/h), and above 50mSv per year.

[93]Source: Decontamination Information (http://josen.env.go.jp/about/method_necessity/method_area_monitoring.html)

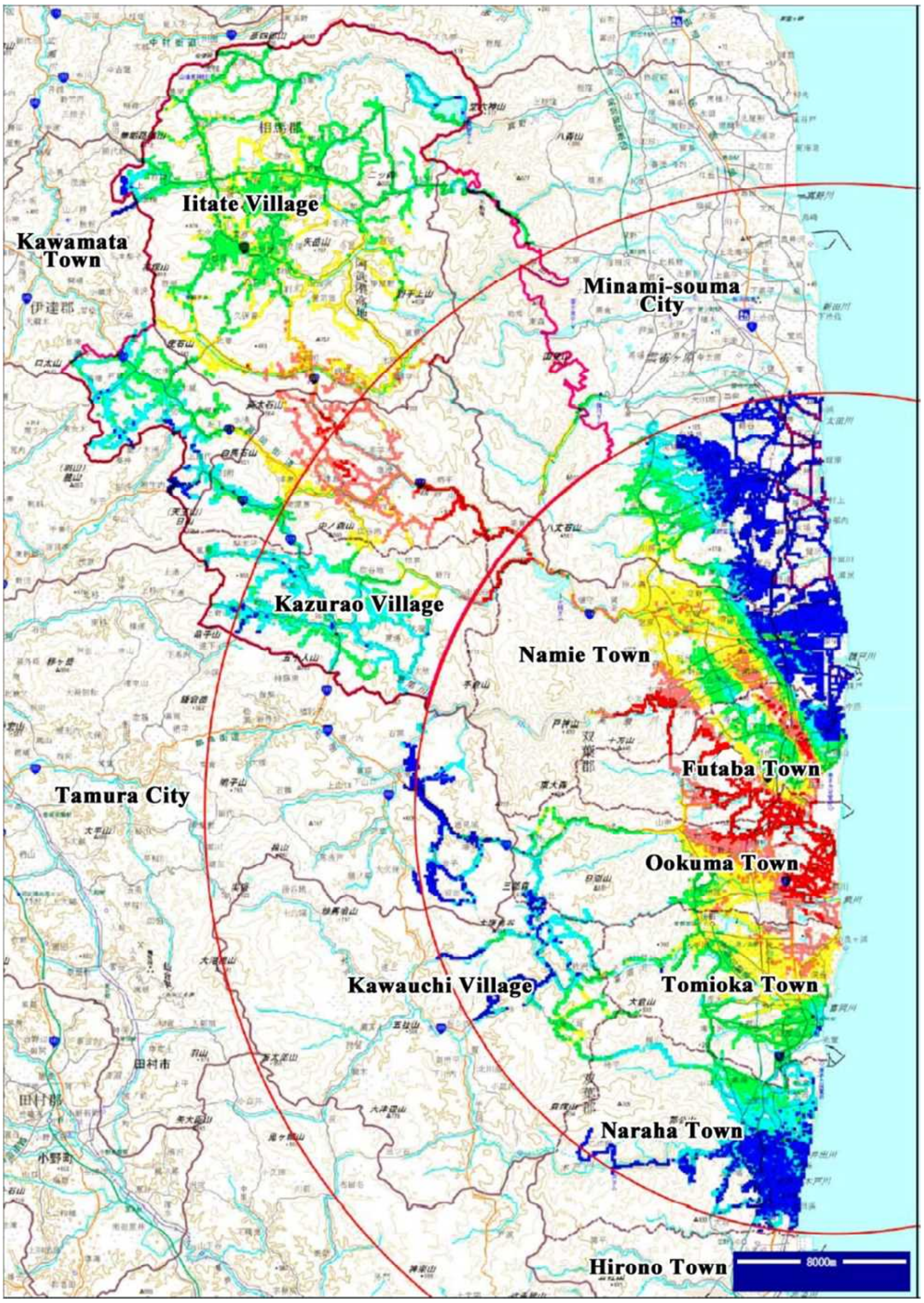


Figure 4-2 General map of the detailed monitoring results[94].

[94]Source: Decontamination Information (http://josen.env.go.jp/area/pdf/monitaring_zentai_final.pdf)

4.2.2. Decontamination Work Ordered by the Ordering Party (MOE)

Decontamination and related works in the Special Decontamination Areas ordered by the MOE followed the government procurement procedures, as in ordinary public works projects: relevant public notices were issued for procurement based on the specifications, decontamination business operators were selected and the orders were issued. Since many of the individual activities of decontamination work were similar to those in ordinary public works projects, the ordering framework for ordinary public works was applied with supplementary additions of matters specific to decontamination work.

The MOE presented common specifications for decontamination and related works for the Special Decontamination Areas (hereafter "Common Specifications"), and formulated common decontamination work specifications to ensure that the details of work agreements and design documents were interpreted and implemented in a uniform manner, and that, by setting out other necessary matters, the agreements were properly executed. In addition, special specifications setting out specific technical requirements (hereafter "Special Specifications") were formulated on an individual project basis for the actual conditions of the area or site subject to decontamination, and individual decontamination projects were carried out based on these Common Specifications and Special Specifications.

It would have taken a long time to commence decontamination projects upon acquisition of consent to the decontamination works and the decontamination methods for each object to be decontaminated from the stakeholders such as land owners, as is practiced in ordinary public works projects. Therefore, the MOE placed an order for decontamination and related works in the Special Decontamination Areas before fixing everything. By using the prior survey results, the order was made based on the estimated decontamination area sizes and number of decontamination target buildings for each type of target object and decontamination method. The quotes could be fixed after the decontamination methods for each target object were fixed and the decontamination area sizes as well as the number of buildings to decontaminate were fixed in the actual project operation. The MOE and decontamination business operators concluded an agreement to adopt a method of calculating payments based on work unit prices and the actual volume of work completed. For the actual operation, the MOE formulated provisional estimation standards of decontamination and related works in the Special Decontamination Areas (hereafter "Provisional Estimation Standards"), in which the unit prices for the work are defined in advance.

The following shows the Common Specifications, Special Specifications, Provisional Estimation Standards, and ordering system and procedures for decontamination and related works in the Special Decontamination Areas as ordered by the MOE.

1) Common Specifications

The Common Specifications describe general parts of technical requirements and work contents which are needed in implementing the work such as the work sequence, qualities of materials to be used, quantities, finished qualities, work methods, etc.

The MOE developed the Common Specifications by incorporating new decontamination work methods based on work experiences and the latest version of the Common Specifications (7^{th} Edition) was issued in April 2014.

Tables 4-2 to 4-6 list the contents of Chapters 1 to 5 of the Common Specifications (7^{th} Edition).

Table 4-2 Contents of "Chapter 1 General Provisions" in the Common Specifications (7th Edition)[95]

Section	Paragraph
Section 1 General Items	1-1-1 Application
	1-1-2 Definition of terms
	1-1-3 Works on Special Decontamination Areas
	1-1-4 Radiation work leader, operation leader
	1-1-5 Check with design document
	1-1-6 Breakdown of contract
	1-1-7 Schedule
	1-1-8 Implementing plan
	1-1-9 Registelation of work performance information
	1-1-10 Supervision personnel
	1-1-11 Commissioned supervisor
	1-1-12 Usage of work land, etc.
	1-1-13 Start of work
	1-1-14 Subcontract of work
	1-1-15 Ledger of working structure
	1-1-16 Cooperation of mutual contractor
	1-1-17 Cooperation for investigation and test
	1-1-18 Temporary halt of work
	1-1-19 Revision of schedule
	1-1-20 Examination committee for design change
	1-1-21 Supplied material and lent itams
	1-1-22 List of decontamination worker and identification card
	1-1-23 Provision of allowance
	1-1-24 Entrance into land and building
	1-1-25 Generated materials at construction site
	1-1-26 Investigation (including confirmation) and witness by supervision staff
	1-1-27 Investigation of work completion
	1-1-28 Investigations of previously finished portion
	1-1-29 Technical investigation
	1-1-30 Execution management
	1-1-31 Performance report
	1-1-32 Management of decontamination workers
	1-1-33 Security during work
	1-1-34 Security measurement for ionizing radiation
	1-1-35 Cleanup
	1-1-36 Accident report
	1-1-37 Environment measurement
	1-1-38 Coordination with peripheral residents
	1-1-39 Care for cultural property
	1-1-40 Management of traffic safety
	1-1-41 Compliance for laws and regulations

95 Source: Decontamination Project Common Specifications (7th Edition) (http://tohoku.env.go.jp/fukushima/to_2014/data/0410ba.pdf) (Table 4-3 to Table 4-6 have the same source.)

Section	Paragraph
	1-1-42 Procedures to public office
	1-1-43 Revision of work duration and work time
	1-1-44 Submitted document
	1-1-45 Damage by inevitable force
	1-1-46 Patent, etc.
	1-1-47 Insurance and compensation for accident
	1-1-48 Measure for specific case
	1-1-49 Confidentiality obligation
	1-1-50 Handling of individual information
	1-1-51 Securement of information security

Table 4-3 Contents of "Chapter 2 Work materials" in the Common Specifications (7th Edition)

Section	Paragraph
Section 1 Application	—
Section 2 Quality and test of work material (including confirmation)	—
Section 3 Work material	2-3-1 Large sandbag, etc.

Table 4-4 Contents of "Chapter 3 Decontamination" in the Common Specifications (7th Edition)

Section	Paragraph
Section 1 Common items	3-1-1 Test of construction
Section 2 Explanation of decontamination method	1. Residents, etc.
	2. School
	3. Park (small)
	4. Park (large)
	5. Large facility
	6. Road
	7. Slope
	8. Farmland
	9. Grass field, Lawn
	10. Orchard
	11. Forest
	12. Deleted
	13. Temporary storage area, etc.
	14. Deleted
	15. Effluent processing

Table 4-5 Contents of "Chapter 4 Work management" in the Common Specifications (7th Edition)

Section	Paragraph
Section 1 Measurement of radiation dose	4-1-1 Common items
	4-1-2 Radiation measurement at measures for decontamination work
	4-1-3 Security, management and transfer of temporary storage area, etc.
Section 2 Management of temporary storage area, etc.	4-2-1 Management of storage area after completion of storage
Section 3 Confirmation of construction result	4-3-1 Confirmation of construction result with decontamination measures on residential district
Section 4 Confirmation investigation	4-4-1 General rule
	4-4-2 Decision of management value
	4-4-3 Implementation of confirmation investigation
Section 5 Handling of removed soil, etc.	4-5-1 Discretion
	4-5-2 Dose measurement
	4-5-3 Grant of identification number and tag, etc.
	4-5-4 Development of storage ledger

Table 4-6 Contents of "Chapter 5 Reporting" in the Common Specifications (7th Edition)

Section	Paragraph
Section 1 Report and submittal document	5-1-1 Submittal document
	5-1-2 decontamination management information
	5-1-3 Report of decontamination result on residential district, etc.
Section 2 Report of decontamination result to related persos	5-2-1 Report of decontamination result on residential district, etc. to related persons

(2) Special Specifications

The Special Specifications supplement the Common Specifications and specify details or specific technical requirements in individual decontamination tasks, considering the actual situations of the area or site to be decontaminated. The Special Specifications were presented as a supplement to the Common Specifications with specific notes in the procurement for individual decontamination tasks.

(3) Provisional Estimation Standards

The Provisional Estimation Standards was developed for estimating costs for decontamination and related works in the Special Decontamination Areas ordered by the MOE. The Provisional Estimation Standards may be excluded from application, when their application is extremely inadequate or difficult because of diverse conditions of the site or the natural environment.

The Provisional Estimation Standards specify materials and equipment needed, workload, unit prices of machinery, workforces, expenses, etc. required for implementing the decontamination and related works. The construction cost can be calculated based on these specifications.

The first edition was developed in May 2012. Thereafter the Provisional Estimation Standards were revised to match the actual site situations based on experiences in decontamination projects, e.g., incorporating new work methods. In April 2014, the 7th Edition was put into effect (Provisional Estimation Standards (7th Edition)).

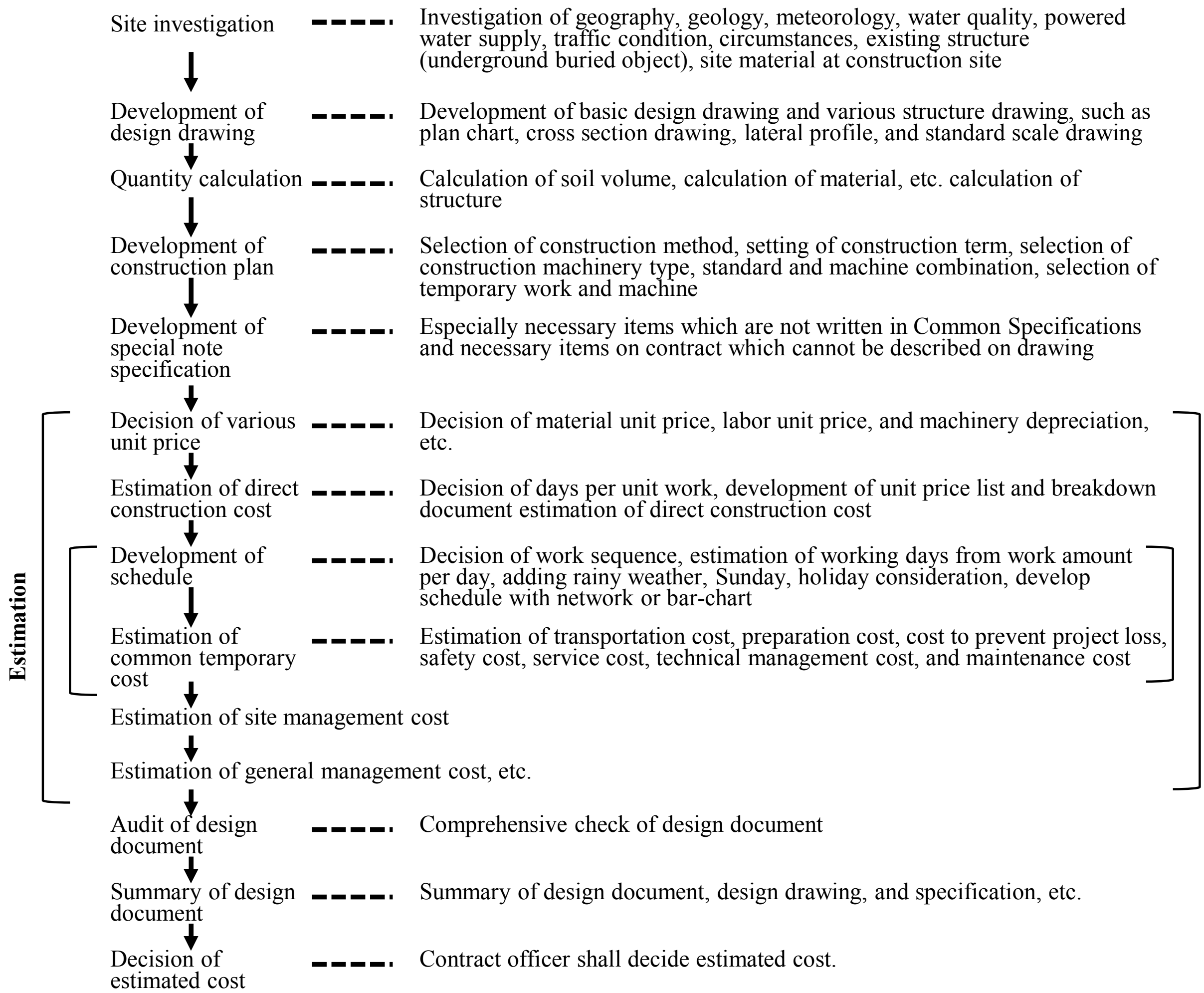


Figure 4-3 Construction cost estimation flow[96].

The Provisional Estimation Standards specify workload needed for each object to be decontaminated and the decontamination method in terms of workforce, quantities generated for removal, and materials and equipment required per unit area for decontamination tasks. An example of workload is shown below for the work of removing sediments from residential area roofs and the like (other than concrete roofs). It specifies 0.50 work supervisor and 3.20 decontamination workers are required per 1,300m^2 area to be decontaminated.

The workload developed in the Special Specifications by the MOE was based on two types of results: the results of the "decontamination model projects" performed by the JAEA

[96]Source: Decontamination Construction Project Management Standards in the Special Decontamination Areas (7th Edition) (http://tohoku.env.go.jp/fukushima/to_2014/data/0410aa.pdf) (Figure 4-4 has the same source.)

Fukushima Technology Headquarters in JFY 2011 under consignment by the Cabinet Office for verifying decontamination techniques required for effective decontamination in high-dose areas; and the results of independent decontamination projects performed by municipalities in Fukushima Prefecture.

Title	Standard	Unit	Quantity	Summary
●Labor cost				
Work supervisor		Person	0.50	
Decontamination worker		Person	3.20	
●Material cost				
Large sandbag		Bag		Later
●Miscellaneous cost				
Miscellaneous cost		%	1.0	1% of labor cost
Total				

Miscellaneous cost include pitchfork, etc. and added above percentage to labor cost.

Figure 4-4 Example of workload.
(Sediment removal from a roof in a residential area (roof material other than concrete))

It is difficult to show simply the cost of decontamination work, since it is affected by various factors such as: the size/extent of houses/land; materials of roofs and walls; extent and conditions of gardens (presence of garden trees, and others); availability of aerial lift (bucket crane) work vehicles; necessity to install temporary scaffolds; necessity to replace gravel; necessity to decontaminate surrounding forests; transfer of removed soil and the like to the temporary storage site, etc.

For ordinary residences, the workload per house is estimated at approximately 50 worker-days (about 10 workers working for five days)[97].

(4) Ordering of decontamination and related works

For the ordering of decontamination and related works in the Special Decontamination Areas, the MOE issued, in accordance with the government procurement procedures, a public announcement and notice of Common Specifications, Special Specifications, Provisional Estimation Standards and other relevant documents and publicly advertised for technical proposals. After reviewing the technical proposal documents, the MOE invited public bids and opened them. The decontamination business operators were selected by comprehensive evaluation of cost points and technical evaluation points.

For the public announcement and notice, the MOE coordinated estimation unit prices to decide its estimated price as the ordering party. The unit prices were estimated based on the past examples of public works and the results of decontamination model projects as mentioned in (3) above.

For the Intensive Contamination Survey Areas, the municipal governments developed decontamination work plans, as mentioned in Chapter 1.1.7, and they placed an order for decontamination and related works using the special grant for emergency work of radiation reduction measures of the National Government as the financial resource which was provided based on the decontamination work plans. The special grants cover decontamination methods to be used in relatively high dose areas and in relatively low dose areas. For example: for the

[97]Source: "On-site explanation of decontamination plan and request for understanding of implementation for decontamination works" (http://www.katsurao.org/uploaded/attachment/6.pdf)

work to decontaminate a stand-alone house in a relatively high dose area, such work methods are added as: (i) removing surface soil, covering with fresh soil, and consolidating for restoring the gardens and the like to the original state; (ii) upturning, (iii) removing contaminated soil, and covering with fresh soil from excavation for field storage development ; or (iv) covering with uncontaminated soil.[98]

4.2.3. Decontamination Work by Decontamination Business Operators

The following is an overview of the decontamination and related works performed by decontamination business operators for an order from the MOE to carry out decontamination in the Special Decontamination Areas.

（1） Development of work plans

Prior to the commencement of decontamination work, decontamination business operators develop a comprehensive work plan including all necessary steps and methods to complete the project, and submit it to the MOE supervisor.

It should be noted that this comprehensive work plan describes an overview of the work, the overall schedule, site organizational chart, work methods (including test work methods and evaluation methods), work management plan, safety management plan (including matters related to radiation protection, and methods to prevent the spread of contamination), and emergency systems and responses, etc.

（2） Development of organizational structure for implementation

1）Designation of the radiation control officer and work leaders

Decontamination business operators are required to designate a person to direct and supervise the radiation management of decontamination workers (radiation control officer), and a person in each work unit (work group) to lead the group's activities (work leader).

The radiation control officer is in charge of the following activities.

- Conducting special education for decontamination workers based on Article 19 of the Ionizing Radiation Ordinance for Decontamination
- Instructing decontamination workers thoroughly in proper wearing of protective clothes and equipment according to the work contents
- Instructing decontamination workers in thoroughly practicing proper operation of machines and equipment necessary to control ionizing radiation
- Inspecting in advance machines, equipment and the like which are necessary to control ionizing radiation, and securing necessary functions and quantities
- Inspecting in advance protective clothes, equipment and the like, and securing necessary functions and quantities
- Controling access of persons not engaged in the work to the site
- Supervising decontamination workers in using radiation measuring instruments
- Understanding the work sequence, work contents, and working environment such as the average air dose rate at the working location, and assisting the acting site manager and similar responsible person(s) at meeting(s) for work procedures before starting the work
- Administrating properly the decontamination workers' roster and their radiation passbooks
- Administrating the records of radiation exposure dose measurements of

[98]Source: Ministry of the Environment (MOE), "Radiation reduction measures special urgent project subsidyhandling instructions" (tentative translation)

decontamination workers

2) Preparation of rosters of decontamination workers and their identification cards

Decontamination business operators are required to prepare a roster of decontamination workers in which a record is made for each worker before they begin the designated decontamination work, their name, age, job title, and radiation passbook registration number. When the decontamination workers terminate their engagement in the designated work, the decontamination business operators remove them from the roster. Decontamination business operators are required to check decontamination workers have or do not have their radiation passbooks at the time they start the decontamination work. If workers have radiation passbooks, the decontamination business operator record the registration numbers in the roster; workers who do not have the radiation passbook are required to get it by the time they leave the designated work.

In addition, decontamination business operators are required to submit requests to the MOE supervisor for personal identification cards for each decontamination worker, and upon receiving the issued cards, ensure that decontamination workers always carry these cards with them while working.

(3) Test work

Test work is carried out for the purpose of choosing the most effective decontamination methods from candidate methods for particular target objects to be decontaminated, which are designated by the MOE supervisor, before commencing the actual decontamination and related works. Once no further significant reductions can be observed in radiation dose rates, even with repeated decontamination processes, the decontamination business operators report this to the MOE supervisor and proceed at his/her direction.

This is due to the reality that, unless test work is carried out in actual site conditions, the optimum parameters in decontamination work cannot be determined, for example, the number of steps for wiping work, the depth and speed of deep ploughing work, the water jet pressure and moving speed of high-pressure road surface cleaners, etc. Specifically, for example, the surface dose rate can be further reduced with two wiping steps than with only one, and further with three than with only two, but after a certain number of steps the rate of surface dose reduction declines. Increase of wiping steps has a disadvantage, too. A new paper towel or rag cleaning face is used in each step of wiping. Consequently, an increase in the number of steps of wiping causes not only increased work time but also an increase of materials and waste. In deep plowing work, the standard plowing depth is 30 cm for a good decontamination effect, but when the soil base is shallow, stones may be turned up in the surface layer or water leaks from rice fields may be caused. Coordination becomes necessary for setting the best parameter for a particular decontamination target. Also in deep plowing work, higher moving speeds of the machinery (tilling tractors) may shorten the work time, but this may not stir the soil enough to achieve a sufficient decontamination effect.

Test work should be implemented considering the following items.

(i) Decontamination business operators are required to prepare the test work plan and submit the document to the MOE supervisor; the document describes the decontamination flow, test locations, number of test points, measurement methods (including measuring equipment), number of tests, etc. for the decontamination objects and decontamination methods as designated by the MOE supervisor.

(ii) The decontamination flow should include several cases in which parameters possibly affecting the decontamination rates (e.g., work time per unit area, number of tests, test location, water pressure for high-pressure washing, and distance between the jet nozzle and ground, etc.) are changed.

(iii) Test locations and points for the target objects to be decontaminated and methods thereof designated by the MOE supervisor should be chosen with a good balance that considers the situation in the area where the decontamination measures are to be implemented.

(4) Implementation of decontamination projects

The Common Specifications specify decontamination methods for each target object to be decontaminated. Prior to commencing the work, decontamination business operators prepare the comprehensive work (or construction) plans, including procedures, methods and all other necessary items required for completion of the project, and submit them to the MOE supervisor.

The decontamination work covers not only decontamination for reducing air dose rates in a narrow sense, but also the methods for pre-decontamination works and post-decontamination works for restoration. For example "cleaning by road sweepers" (6.1.2.6) has the purpose of being a prior preparation to decontamination work or the purpose of maintenance. "Restoration of soil fertility" (8.1.2.7-(1) and others) for farmland can be regarded as a post-process work (restoration to the state before contamination). On the other hand, there are such methods as "sediment removal" (1.1.1.1 and others), which, depending on actual site conditions, can be regarded as methods for reducing the air dose rate in a narrow sense of decontamination, or can be also regarded as a preparatory process before "wiping" (1.1.1.2 and others) or "brush cleaning" (1.1.1.3 and others).

Table 4-7 Decontamination methods for each decontamination target [99]

Target			Decontamination methods
1. Residential areas, etc.	1.1 Roofs, rooftops	1.1.1 Roofs (all materials except concrete)	1.1.1.1 Sediment removal
			1.1.1.2 Wiping
			1.1.1.3 Brush cleaning
		1.1.2 Roofs (concrete)	1.1.2.1 Sediment removal
			1.1.2.2 Wiping
			1.1.2.3 Brush cleaning
	1.2 Walls, Fences	1.2.1 Except earthen walls	1.2.1.1 Wiping
			1.2.1.2 Brush cleaning
		1.2.2 Earthen walls	1.2.2.1 Wiping
	1.3 Gutters	1.3.1 Eave gutters	1.3.1.1 Sediment removal
			1.3.1.2 Wiping
			1.3.1.3High-pressure washing
		1.3.2 Downspouts	1.3.2.1 High-pressure washing
	1.4 Gardens, etc.	1.4.1 Unpaved surfaces	1.4.1.1 Sediment removal
			1.4.1.2 Weeding, mowing
			1.4.1.3 Close mowing of lawns
			1.4.1.4 Peeling off grass and lawn top layer
			1.4.1.5 Sodding
			1.4.1.6 High-pressure washing of gravel and crushed stone

99 Source: Decontamination Project Common Specifications (7^{th} Edition) (http://tohoku.env.go.jp/fukushima/to_2014/data/0410ba.pdf)

Target			Decontamination methods
			1.4.1.7 Removal of gravel and crushed stone
			1.4.1.8 Covering of gravel and crushed stone
			1.4.1.9 Peeling off topsoil
			1.4.1.10 Covering the ground surface
			1.4.1.11 Topsoil removal in tree root vicinity etc.
			1.4.1.12 Pruning of garden trees
			1.4.1.13 Trimming of garden trees
			1.4.1.14 (Deleted)
			1.4.1.15 Upturning soil
		1.4.2 Paved surfaces	1.4.2.1 Sediment removal
			1.4.2.2 Brush cleaning
			1.4.2.3 High-pressure washing
			1.4.2.4 Peeling
			1.4.2.5 Abrasive material blasting
School buildings	2.1 Roofs, roof tops	－	2.1.1.1 Sediment removal
			2.1.1.2 Wiping
			2.1.1.3 Brush cleaning
			2.1.1.4 High-pressure washing
	2.2 Walls, fences	－	2.2.1.1 Wiping
			2.2.1.2 Brush cleaning
			2.2.1.3 High-pressure flushing
	2.3 Gutters	2.3.1 Eave gutters	2.3.1.1 Sediment removal
			2.3.1.2 Wiping
			2.3.1.3 High-pressure washing
		2.3.2 Downspouts	2.3.2.1 High-pressure washing
	2.4 Ground surfaces, etc.	2.4.1 Sediment	2.4.1.1 Sediment removal
		2.4.2 Grass areas, Lawns	2.4.2.1 Weeding, Mowing
			2.4.2.2 Close mowing of lawns
			2.4.2.3 Peeling off grass and lawn top layer
			2.4.2.4 Sodding
		2.4.3 Gravel, crushed stone	2.4.3.1 High-pressure washing of gravel and crushed stone
			2.4.3.2 Removal of gravel and crushed stone
			2.4.3.3 Covering of gravel and crushed stone
		2.4.4 Soil	2.4.4.1 Topsoil removal around drain outlets, eave

Target			Decontamination methods
			gutter outlets
			2.4.4.2 Peeling off topsoil
			2.4.4.3 Covering of ground surface
			2.4.4.4 Upturning
		2.4.5 Plantings	2.4.5.1 Topsoil removal in tree root vicinity etc.
			2.4.5.2 Pruning of plantings
			2.4.5.3 Trimming of trees
		2.4.6 Paved surfaces	2.4.6.1 Sediment removal
			2.4.6.2 Brush cleaning
			2.4.6.3 High-pressure washing
			2.4.6.4(1)、2.4.6.4(2) Scraping
			2.4.6.5 Abrasive material blasting
			2.4.6.6 Superhigh pressure flushing
			2.4.6.7 Resurfacing
	2.5 Play equipment, etc.	2.5.1 Play equipment, etc.	2.5.1.1 Wiping, Brush cleaning, Scraping
3. Parks (small)	3.1 Roofs, rooftops	―	3.1.1.1 Sediment removal
			3.1.1.2 Wiping
			3.1.1.3 Brush cleaning
			3.1.1.4 High-pressure washing
	3.2 Walls, Fences	3.2.1 Walls, Fences	3.2.1.1 Wiping
			3.2.1.2 Brush cleaning
			3.2.1.3 High-pressure washing
	3.3 Gutters	3.3.1 Eave gutters	3.3.1.1 Wiping
			3.3.1.2 Brush cleaning
			3.3.1.3 High-pressurewashing
		3.3.2 Downspouts	3.3.2.1 High-pressure washing
	3.4 Grounds, etc.	3.4.1 Sediment	3.4.1.1 Sediment removal
		3.4.2 Grass areas, Lawns	3.4.2.1 Weeding, mowing
			3.4.2.2 Close mowing of lawns
			3.4.2.3 Peeling off grass and lawn top layer
			3.4.2.4 Sodding
		3.4.3 Gravel, Crushed stone	3.4.3.1 High-pressure washing of gravel and crushed stone
			3.4.3.2 Removal of gravel and crushed stone
			3.4.3.3 Covering of gravel and crushed stone

Target			Decontamination methods
		3.4.4 Soil	3.4.4.1 Peeling off topsoil
			3.4.4.2 Covering of ground surface
			3.4.4.3 Upturning
		3.4.5 Plantings	3.4.5.1 Topsoil removal in tree root vicinity etc.
			3.4.5.2 Pruning of plantings
			3.4.5.3 Trimming of trees
		3.4.6 Paved surfaces	3.4.6.1 Sediment removal
			3.4.6.2 Brush cleaning
			3.4.6.3 High-pressure washing
			3.4.6.4 Peeling
			3.4.6.5 Abrasive material blasting
	3.5 Play equipment, etc.	3.5.1 Play equipment, etc.	3.5.1.1 Wiping, Brush cleaning, Peeling
3. Parks (big)	4.1 Roofs, Rooftops	―	4.1.1.1 Sediment removal
			4.1.1.2 Wiping
			4.1.1.3 Brush cleaning
			4.1.1.4 High-pressure washing
	4.2 Walls, Fences	4.2.1 Walls, Fences	4.2.1.1 Wiping
			4.2.1.2 Brush cleaning
			4.2.1.3 High-pressure washing
	4.3 Gutters	4.3.1 Eave gutters	4.3.1.1 Sediment removal
			4.3.1.2 Wiping
			4.3.1.3 High-pressure washing
		4.3.2 Downspouts	4.3.2.1 High-pressure washing
	4.4 Ground surfaces, etc.	4.4.1 Sediment	4.4.1.1 Sediment removal
		4.4.2 Grass areas, Lawns	4.4.2.1 Weeding, mowing
			4.4.2.2 Close mowing of lawns
			4.4.2.3 Peeling off grass and lawn top layer
			4.4.2.4 Sodding
		4.4.3 Gravel, Crushed stone	4.4.3.1 High-pressure washing of gravel and crushed stone
			4.4.3.2 Removal of gravel and crushed stone
			4.4.3.3 Covering of gravel and crushed stone
		4.4.4 Soil	4.4.4.1 Topsoil removal around drain outlets, Eave gutter outlets
			4.4.4.2 Peeling off topsoil
			4.4.4.3 Covering of ground surface

Target			Decontamination methods
			4.4.4.4 Upturning
		4.4.5 Plantings	4.4.5.1 Topsoil removal in tree root vicinity etc.
			4.4.5.2 Pruning of plantings
			4.4.5.3 Trimming of trees
		4.4.6 Paved surfaces	4.4.6.1 Sediment removal
			4.4.6.2 Brush cleaning
			4.4.6.3 High-pressure washing
			4.4.6.4 Peeling
			4.4.6.5 Abrasive material blasting
			4.4.6.6 Super-high-pressure washing
			4.4.6.7 Repaving
	4.5 Play equipment, etc.	4.5.1 Play equipment, etc.	4.5.1.1 Swabbing, cleaning, peeling
5. Large facilities	5.1 Roofs, Rooftops	5.1.1 Roofs, Rooftops	5.1.1.1 Sediment removal
			5.1.1.2 Wiping
			5.1.1.3 Brush cleaning
			5.1.1.4 High-pressure washing
	5.2 Walls, Fences	5.2.1 Walls, Fences	5.2.1.1 Wiping
			5.2.1.2 Brush cleaning
			5.2.1.3 High-pressure washing
	5.3 Gutters	5.3.1 Eave gutters	5.3.1.1 Sediment removal
			5.3.1.2 Wiping
			5.3.1.3 High-pressure washing
	5.4 Ground surfaces, etc.	5.4.1 Sediment	5.4.1.1 Sediment removal
		5.4.2 Grass areas, Lawns	5.4.2.1 Weeding, mowing
			5.4.2.2 Close mowing of lawns
			5.4.2.3 Peeling off grass and lawn top layer
			5.4.2.4 Sodding
		5.4.3 Gravel, crushed stone	5.4.3.1 High-pressure flush of gravel and crushed stone
			5.4.3.2 Removal of gravel and crushed stone
			5.4.3.3 Covering of gravel and crushed stone
		5.4.4 Soil	5.4.4.1 Topsoil removal around drain outlets, Eave gutter outlets
			5.4.4.2 Peeling off topsoil
			5.4.4.3 Covering of ground surface
			5.4.4.4 Upturning
		5.4.5 Plantings	5.4.5.1 Topsoil removal in tree root vicinity etc.

Target			Decontamination methods
			5.4.5.2 Pruning of plantings
			5.4.5.3 Trimming of trees
		5.4.6 Parking lots (concrete, asphalt)	5.4.6.1 Sediment removal
			5.4.6.2 Brush cleaning
			5.4.6.3 High-pressure washing
			5.4.6.4 Peeling
			5.4.6.5 Abrasive material blasting
			5.4.6.6 Super-high-pressure washing
			5.4.6.7 Repaving
	5.5 Play equipment, etc.	5.5.1 Play equipment, etc.	5.5.1.1 Wiping, Brush cleaning, Peeling
6. Road	6.1 Paved road	6.1.1 Sediment	6.1.1.1 Sediment removal
		6.1.2 Road, Sidewalk	6.1.2.1 High-pressure washing
			6.1.2.2 Peeling
			6.1.2.3 Abrasive material blasting
			6.1.2.4 Super-high-pressure washing
			6.1.2.5 Repaving
			6.1.2.6 Cleaning with road sweepers
	6.2 Unpaved roads	6.2.1 Road surfaces (soil)	6.2.1.1-(1) Weeding
			6.2.1.1-(2) Sediment removal
			6.2.1.2 Side ditches, etc.
			6.2.1.3 Covering of ground surface
			6.2.1.4 Upturning
		6.2.2 Road surfaces (gravel, crushed stone roads)	6.2.2.1-(1) Weeding
			6.2.2.1-(2) Sediment removal
			6.2.2.2 High-pressure washing of gravel and crushed stone
			6.2.2.3 Removal of gravel and crushed stone
			6.2.2.4 Covering of gravel and crushed stone
	6.3 Guardrails	6.3.1 Guardrails	6.3.1.1 Brush cleaning
			6.3.1.2 High-pressure washing
			6.3.1.3 Wiping
	6.4 Side ditches , etc.	6.4.1 Side ditches , etc.	6.4.1.1 Bottom sediment removal, etc.
	6.5 Pedestrian bridges	6.5.1 Pedestrian bridges	6.5.1.1 Sediment removal
			6.5.1.2 High-pressure washing
			6.5.1.3 Wiping

Target			Decontamination methods
			6.5.1.4 Brush cleaning
	6.6 Roadside trees	6.6.1 Sediment	6.6.1.1 Sediment removal
		6.6.2 Grass	6.6.2.1 Weeding, mowing
		6.6.3 Roadside trees	6.6.3.1 Soil removal around root area of roadside trees
			6.6.3.2 Debranching of roadside trees
7. Slopes	7.1 Slopes	7.1.1 Sediments (grass, fallen leaves, etc.)	7.1.1.1 Sediment removal
8. Farmland	8.1 Rice paddies	8.1.1 Grass	8.1.1.1-(1) Manual weeding
			8.1.1.1-(2) Machine weeding
			8.1.1.1-(3) Buildup of weeding material
			8.1.1.1-(4) Packing
			8.1.1.1-(5) Small transfer in site
		8.1.2 Soil	8.1.2.1-(1) Bump leveling
			8.1.2.1-(2) Surface fixation material dispersion
			8.1.2.2-(1)-①、8.1.2.2-(1)-②Peeling off surface soil (standard transportation method)
			8.1.2.2-(1)-③ Packing (standard transportation method)
			8.1.2.2-(1)-④ Small transport vehicles (standard transportation method)
			8.1.2.2-(2)-① Peeling off surface soil (suction method)
			8.1.2.2-(2)-② Packing (suction method)
			8.1.2.2-(2)-③ Small transport vehicles (suction method)
			8.1.2.3 Deleted
			8.1.2.4-(1) Reverse cultivation (plowing 30cm)
			8.1.2.4-(2) Reverse cultivation (plowing 45cm)
			8.1.2.4-(3) Base land preparation
			8.1.2.4-(4) Turn plowing
			8.1.2.5 Deep plowing
			8.1.2.6 Adding soil
			8.1.2.7-(1) Restoration of soil fertility (soil improvement agent

Target			Decontamination methods
			dispersal)
			8.1.2.7-(2) Restoration of soil fertility (zeolite dispersal)
			8.1.2.8 Upturning
	8.2 Fields	8.2.1 Grass	8.2.1.1 Weeding
		8.2.2 Soil	8.2.2.1 Surface fixation material dispersion
			8.2.2.2-(1) Peeling off topsoil (standard transportation method)
			8.2.2.2-(2) Peeling off surface soil (suction method)
			8.2.2.3 Deleted
			8.2.2.4 Reverse cultivation
			8.2.2.5 Deep plowing
			8.2.2.6 Adding soil
			8.2.2.7 Land power recovery
			8.2.2.8 Upturning
	8.3 Meadows	8.3.1 Grass	8.3.1.1 Weeding
			8.3.1.2 Deleted
			8.3.1.3-(1) Seeding (dispersion)
			8.3.1.3-(2) Seeding (suppression)
		8.3.2 Soil	8.3.2.1 Peeling off surface soil
			8.3.2.2 Reverse cultivation
			8.3.2.3 Deep plowing
			8.3.2.4 Adding soil
			8.3.2.5 Land nutrient recovery
	8.4 Water channels	8.4.1 Water channels	8.4.1.1-(1) Bottom sediments removal, etc. (earth and sand removal)
			8.4.1.1-(2) Bottom sediments removal, etc. (packing)
	8.5 Ridge fronts	8.5.1 Ridge fronts	8.5.1.1-(1) Sediment removal
			8.5.1.1-(2) Weeding
			8.5.1.2-(1) Peeling off surface soil
			8.5.1.2-(2) Packing
			8.5.1.3 Ridge front recovery
9. Grass areas, lawns	9.1 Shrubs (dense)	9.1.1 Shrubs (dense)	9.1.1.1 Trimming
	9.2 Shrubs (coarse)	9.2.1 Shrubs (coarse)	9.2.1.1 Trimming
10. Orchards	10.1 Orchards	10.1.1 Sediment	10.1.1.1 Sediment removal
		10.1.2 Grass	10.1.2.1 Weeding
		10.1.3 Orchard	10.1.3.1 Peeling off coarse

Target			Decontamination methods
		tree	bark
			10.1.3.2 High-pressure washing of tree bark
			10.1.3.3 Pruning of orchard trees
			10.1.3.4 Trimming of orchard trees
		10.1.4 Soil	10.1.4.1 Peeling off surface soil
			10.1.4.2 Adding soil
11. Forests	11.1 Evergreen needle-leaved trees	11.1.1 Organic sediments	11.1.1.1-(1)、11.1.1.1-(2)、11.1.1.1-(3) Removal of organic sediments
			11.1.1.1-(4) Removal of organic sediments (non-management zone)
			11.1.1.1-(5) Arrangement of cutoff chips
		11.1.2 Soil	11.1.2.1 Prevention of re-spreading (soil loading)
			11.1.2.2 Prevention of re-spreading (board rack)
		11.1.3 Timber	11.1.3.1-(1)、11.1.3.1-(2)、11.1.3.1-(3) Pruning of needle leaf trees, collection of branches
		11.1.4 Rough cutting	11.1.4.1 Pruning underbrush, shrubs
		11.1.5 Removal of residual organic sediments	11.1.5.1 Removal of residual organic sediments
	11.2 Deciduous broadleaf trees	11.2.1 Organic sediments	11.2.1.1 Removal of organic sediments
			11.2.1.2 Removal of organic sediments (non-management zone)
		11.2.2 Soil	11.2.2.1 Prevention of re-spreading (soil loading)
			11.2.2.2 Prevention of re-spreading (board rack)
		11.2.3 Timber	11.2.3.1 Fascine bonding
		11.2.4 Rough cutting	11.2.4.1 Pruning underbrush, shrubs
		11.2.5 Removal of residual organic sediments	11.2.5.1 Removal of residual organic sediments
	11.3 Bushes	11.3.1 Organic sediments	11.3.1.1 Removal of organic sediments
			11.3.1.2 Removal of organic sediments (non-management zone)

Target			Decontamination methods
		11.3.2 Soil	11.3.2.1 Prevention of re-spreading (soil loading)
			11.3.2.2 Prevention of re-spreading (board rack)
		11.3.3 Timber	11.3.3.1 Fascine bonding
		11.3.4 Rough cutting	11.3.4.1 Pruning underbrush, shrubs
		11.3.5 Removal of residual organic sediments	11.3.5.1 Removal of residual organic sediments
12. (Deleted)	—	—	—
13. Temporary installations, etc.	—	—	13.1.1.1 Groundwater investigation for storage area
			13.1.1.2 Weeding
			13.1.1.3 Trimming of shrubs (thick)
			13.1.1.4 Trimming of shrubs (coarse)
			13.1.1.5-(1) Logging, root removing (logging work)
			13.1.1.5-(2) Logging, root removing (root removing work)
			13.1.1.5-(3) Logging, root removing (accumulation work)
			13.1.1.6 Leveling
			13.1.1.7 Cutting earth, Filling earth
			13.1.1.8 Covering of gravel , crushed stone
			13.1.1.9-(1) Installation of bottom sheets (water blocking sheet)
			13.1.1.9-(2) Installation of protection layers
			13.1.1.9-(3) Installation of upper sheets (breathable waterproof sheets and water blocking sheets)
			13.1.1.10 Leachate collection channels, Leachate collection pipe facilities
			13.1.1.11 Installation of leachate collection facilities
			13.1.1.12 Installation of surface water collection facilities
			13.1.1.13 Deleted
			13.1.1.14 Storage carry-in,

Target			Decontamination methods
			installation
			13.1.1.15 Lateral shielding
			13.1.1.16 Upper shielding
			13.1.1.17 End treatment
			13.1.1.18 Ancillary facilities
			13.1.1.19 Installation of radiation tubes (gas-vent pipes), gas-vent outlets
			13.1.1.20 Installation of thermometers
14. Deleted	—	—	—
15. Effluent treatment	15.1 Effluent treatment	15.1.1 Effluent treatment	15.1.1.1 Treatment of discharged water (precipitation treatment)
			15.1.1.2 Sludge treatment
			15.1.1.3-(1) Installation of turbid water treatment facilities
			15.1.1.3-(2) Water treatment facilities for removal of turbidity

(5) Project management

The Common Specifications (7th Edition) specify the project management methods for radiation dose measurements, administration of temporary storage sites, and confirmation of the work results.

1) Radiation dose measurements

Decontamination business operators are required to select appropriate measuring instruments which have sufficient performance for measurements, taking into account the environment, use conditions, and other matters. Decontamination business operators also ensure that appropriate numbers of instruments are available and calibrated in advance. Decontamination business operators report to the MOE supervisor the name, serial number, date of calibration, term of validity and error values (the variance in measurements at the same measuring point) of the instruments, and conduct daily inspections of them.

When measuring air dose rates, radiation survey meters which meet JIS Z 4333 specifications and the following performance and requirements should be used.

- Type of radiation to measure: gamma rays, X-rays
- Reference radiation source for calibration: cesium-137
- Display unit: μSv/h
- Relative standard errors[100]: below ±15%
- Energy characteristics: energy range 60 keV to 1.5 MeV, sensitivity 0.85 to 1.15
- Directional characteristics: below ±25% (angular range of ±90°)
- Response time or time constant: to be specified

[100] The relative standard error is the deviation of readings of the instrument from the reference radiation dose, expressed in percent. (Some instruments use the terms “reading accuracy” or “relative readings error” with the same meaning)

- Service temperature range: covers -10 to +40 deg C

On the other hand, when measuring surface contamination densities, surface contamination survey meters which meet performance and other requirements specified in JIS Z 4329 should be used, and the results should be recorded as count rates (counts per minute, cpm).

The measurement of radiation dose rate should be done in principle under dry conditions (to avoid shielding influence of moisture), and should follow the specific sequence below.

- Set and fix the time constant at 10 s when measuring radiation.
- Read and record the readings 30 s after fixing the probe (detectors) of the measuring instrument at the measuring point.
- Keep the probe parallel to the ground surface, while facing east and holding the probe as far away from the body as possible for the measurement.
- Take the average of the readings as the measured value.

For those who are not specialists in using radiation measuring instruments, information is provided in the "Performance check-sheet of radiation measuring instruments" (Performance Check-sheet Committee, Japan Electric Measuring Instruments Manufacturers' Association, April 2013) to select the proper instruments.

2） Administration of temporary storage sites

Once all the removed soil and the like have been received, and shielding work above them has been completed, the decontamination business operators are required to commence administration of each temporary storage site and to continue this administration as appropriate in accordance with the direction of the MOE supervisor, until the responsibility of management of temporary storage sites is handed over to the MOE or other operators designated by the MOE.

3） Confirmation of project results

Upon implementation of decontamination and other measures in residential areas and the like, decontamination business operators are required to: compile a report on the work results of these measures; allow the responsible person (foreman or manager) of the operator to check whether the measures have been appropriately implemented in each residential area and the like based on the report; and submit the results to the MOE supervisor.

（6） Check surveys

The goal of decontamination work is to reduce radiation levels, and given that this cannot be confirmed visually, quality management methods are important. For example, it is difficult to judge visually the finished quality of wiping and cleaning after decontamination work. Therefore, MOE personnel randomly choose some part of the surfaces after decontamination, have the decontamination business operators perform their decontamination work again using the same method, and check if there is no further reduction in surface dose rates after this additional decontamination.

In the case of wiping and cleaning, the number of wiping steps and the cleaning speed are set from the test decontamination results as those values which can achieve no further significant radiation dose reduction. Therefore, where wiping and cleaning are finished, no further significant reduction will be anticipated, even if the work is repeated. To the contrary, if the radiation dose is found to have fallen in the check below the control value (the standard deviation of the dose reduction rate before and after the additional check of the decontamination measure), the decontamination measures should be repeated under the direction of the MOE supervisor.

The radiation dose measurements in the check surveys should be carried out before and after the decontamination work using lead blocks in order to shield measurement instruments from radiation emitted by the surroundings. The same measurement instruments should be used before and after the decontamination work to measure the air dose rates at a distance of 1 cm from the surface being checked.

（7） Project management standards

The Decontamination Work Project Control Standards presented in the Common Specifications specify the schedule and progress control, finished quality control, material quality control and photo control.

1） Schedule and progress control

Decontamination business operators are required to perform appropriate schedule controls using maps, networks, bar charts, etc., and to prepare daily work reports from the day of work commencement until the day of its completion. The daily reports should include the weather, workplaces, work contents, list of workers on duty, quantities of finished work, machinery used, radiation dose rates in the work areas, etc. as well as the items instructed, approved, consulted about, etc., and should be accompanied by attachments such as work photos in accordance with the Photo Control Standards, the checklists of the results of decontamination related works.

2） Finished quality control

Decontamination business operators are required to measure the items as specified in the Finished Quality Control Standards for each type of work designated in the Common Specifications, and to prepare and control the Finished Quality Control Sheets which record the compared results of the measured values with the work plan values.

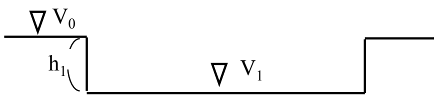
Work		Finished work quality measuring control: Measuring criterion	Finished work quality measuring control: Items	Regulated value (mm)	Remark
Residential area	Removal of gravel and crushed stone (1.4.1.7)	・1 place per work area 1000m²(1place per work site for equal and less than work area 1000m², ・Reference height is defined as the height above sea level lower than the height before work by regulated height (5cm) for the relevant place for each measuring point ・Direct measurement on the basis of the height above sea level for the ground surface after work	Reference height	±10	
	Removal of gravel, and crushed stone (1.4.1.8)	・1 place per work area 1000m²(1place per work site for equal and less than work area 1000m², ・Reference height is defined as the height above sea level before work of "removal of gravel and crushed stone (1.4.1.7)"for the relevant place for each measuring point ・Direct measurement on the basis of the height above sea level for the ground surface after work	Reference height	±10	
	Scraping of surface soil (1.4.1.9)	・1 place per work area 1000m²(1place per work site for equal and less than work area 1000m², ・Reference height is defined as the height above sea level lower than the height before work by regulated height (5cm) for the relevant place for each measuring point ・Direct measurement on the basis of the height above sea level for the ground surface after work	Reference height	±10	
	Covering over ground surface (1.4.1.10)	・1 place per work area 1000m²(1place per work site for equal and less than work area 1000m², ・Reference height is defined as the height above sea level before work of "scraping of surface soil(1.4.1.9) "for the relevant place for each measuring point ・Direct measurement on the basis of the height above sea level for the ground surface after work	Reference height	±10	
	Upturn (1.4.1.15)	・1 place per work area 1000m2(1place per work site for equal and less than work area 1000m2). The following item①should be measured.			
		① ・Reference elevation is defined as the elevation lower than that (V_0) before the work by the standard value (10cm). ・Direct measurement on the basis of the height above sea level for the ground surface after scraping of surface soil 	Reference height	±10	

Figure 4-5 Finished Quality Control Standards (Excerpt)[101].

3）Material quality control

Decontamination business operators are required to ensure appropriately that the quality of materials used in decontamination and related works meet the Material Quality Control Standards.

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[101]Source: Decontamination Construction Project Management Standards in the Special Decontamination Areas (7th Edition) (http://tohoku.env.go.jp/fukushima/to_2014/data/0410aa.pdf) (Figure 4-6 to Figure 4-7 have the same source.)

Type	Class	Category	Test item	Test method	Standard value	Test standard	Remarks
Residential area, School, Park, Large facility, Farm land	Residential area, school, park, large facility, farm land	Mandatory	Measurement of radioactive Cesium density	Gamma- ray spectrometry	Sum of Cesium 134 and Cesium 137 shall be under 400 Bq/kg	Once for each product district before carry-in	

Other quality control is based on "civil engineering work control criteria and its regulated value" (Ministry of Land, Infrastructure, Transport and Tourism).

Figure 4-6 Material Quality Control Standards.

4) Photo management

As a means of managing the construction work, decontamination business operators are required to take photographs, in accordance with the Photo Control Standards, at each construction stage, of the following items: the state of areas that cannot be visually confirmed after the completion of construction work; finished work measurements; material quality control conditions, and accidents during construction. Further, these photos are to be appropriately controlled, stored and submitted at the completion of construction work.

Construction photographs
- **Pictures before start and completion (including previously completed portion)**
- **Picture of construction status**
- **Picture of safety control**
- **Picture of material used for work**
- **Picture of quality control**
- **Picture of finished work control**
- **Picture of disaster**
- **Picture of accident**
- **Others (pollution, circumstance, and compensation)**

Figure 4-7 Classification of work photos (excerpt) in the Photo Control Standards.

4.2.4. Securing of Necessary Resources by Decontamination Business Operators

There were a number of issues faced by decontamination business operators in securing resources needed in the decontamination and related works ordered by the MOE in the Special Decontamination Areas. These issues and the methods for solving them are summarized below.

(1) Issues concerning radiation measurements

1) Procurement and operation of exposure dose measurement apparatuses for workers

External exposure dose of workers can be controlled based on measurements obtained using personal dosimeters (cumulative-type dosimeters or electronic dosimeters). Some decontamination business operators used an access management system and other systems related to the air dose distribution in the workplaces for exposure dose control. Measurements using whole-body counters (WBCs) were used for internal exposure dose control.

Decontamination business operators instructed each worker to wear personal cumulative-type dosimeters and to read the indications before and after the work day for measurement of the exposure dose for that day. The measured data were processed together with the information stored in the data base and used for personal exposure dose control.

On the other hand, individual workers are required to receive medical checks for ionizing radiation in decontamination and related works at the time of employment by the decontamination business operator or at the time of relocation, and periodically after that once in every six months. Internal exposure dose is measured by using WBCs or bioassays, or by evaluating measurement of the air-borne radioactive material concentrations. The WBCs installed in hospitals were used for the evaluations of community residents, too. Since the WBCs are costly, the MOE opened two WBC Inspection Offices, one in Minami-soma City and another in Naraha Town (this has since been moved to Tomioka Town).

The issues for decontamination business operators were the requirements: (i) to manage exposure dose control effectively for a huge number of workers, several thousand (1,000 to 6,000 people) per site; (ii) to manage screening processes of those workers which were concentrated exclusively at limited time spans of the day (lunch time, end of the day, etc.); and (iii) to handle a concentration of new workers and leaving workers at limited times of the year (for example, at the end of the fiscal year).

To cope with these issues, some decontamination business operators adopted a more efficient dose control system by mechanizing the screening equipment such as hand-foot monitors or the like by using IT tools. There was also a case in which one decontamination business operator donated a WBC to the local hospital and allowed it to be used for evaluation of local residents when not being used to evaluate the business operator's workers. Another decontamination business operator applied fingerprint authentication devices for its radiation control system (Fig.4-8).

Issues, however, remain in balancing cost and efficiency improvement by mechanization and automation in small-sized or short-term decontamination projects.

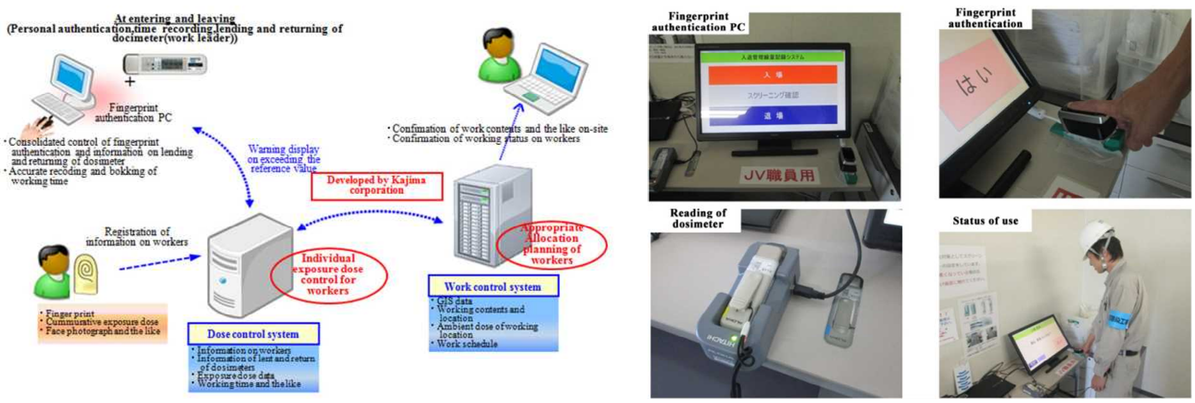

Figure 4-8 Example of radiation control using a fingerprint authentication device[102].

2) Measurement of air dose rates and other quantities

Scintillation survey meters were mainly used to measure air dose rates of gamma-rays and surface dose rates. GM survey meters were used to measure beta-rays emitted from the objects to be decontaminated in order to find the degree of the contamination of the surfaces and also to check the decontamination effects after decontamination.

Collimators were used in many cases in order to avoid the influence of background radiation from the surroundings, when using scintillation survey meters to measure the

[102]Source: Kajima Corporation (Figure 4-9 has the same source.)

degree of the contamination or to check the decontamination effects, and using GM survey meters to measure the surface contamination densities. For cases in which measurements were implemented without using collimators, these were for unstable places such as on walls or roofs where it was not possible to attach the collimators or there were risks of damage to the targets. Regarding the collimators, if they were used in the measurements before decontamination they had to be used in the measurements after it and vice versa.

The measurement positions must be known geographically which presents some issues.

- The conventional position measuring GNSS (global navigational satellite system; using a fixed type position checking apparatus) has good accuracy, but is bulky and so heavy that it requires two persons to carry it. On the other hand, the tablet-embedded global positioning system (GPS) is light and easy to handle, but it has poor accuracy and needs much time to locate the measurement points, especially for inaccurate data.
- One person reads the measurements while a second person records the data on paper or a tablet device. Such work flow is inefficient and has the risk of reading errors depending upon how proficient the persons are.

To cope with these issues, a wearable GNSS system was used by one decontamination business operator in measuring the air dose rates. The system had several advantages: (i) one worker instead of two was needed for measuring and recording data because the equipment weight was reduced to 1/5 that of the conventional apparatus and measured data were sent by a wireless transmitter to a recording unit; (ii) work efficiency was improved more than ten-fold by having a high-speed navigation system like that of a car-navigation system; and (iii) the progress of decontamination work can be visualized using the measured results and the geographic information system (GIS) (Fig.4-9).

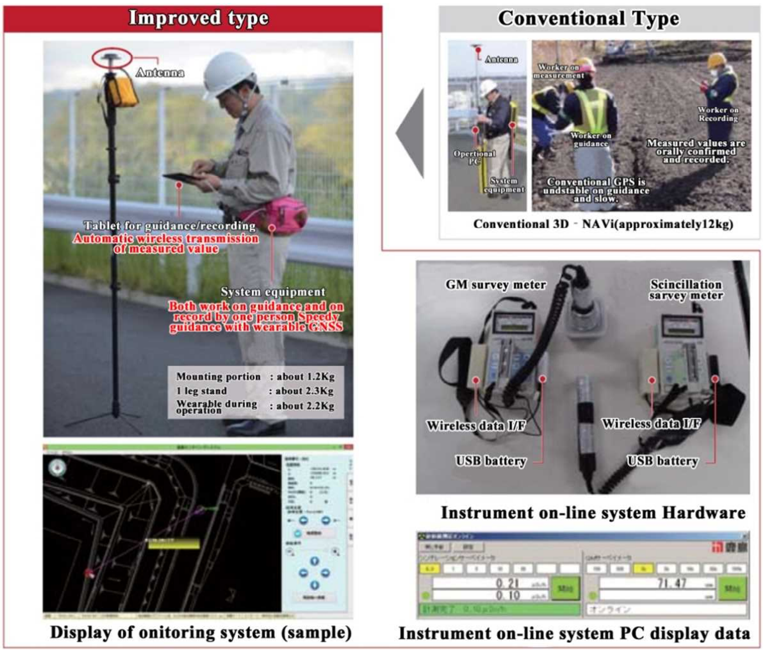

Figure 4-9 Example photos showing use of GNSS-based air dose rate measurement system.

(2) Materials and equipment for use in decontamination work

The "Decontamination Guidelines" requires tools be prepared that are necessary for decontamination and related works and for collection of removed soil and other wastes, depending on the decontamination target objects or work circumstances. Examples of decontamination tools for the work on structures like buildings are shown in Figure 4-10.

Restoration and reconstruction work from the damage by the Great East Japan Earthquake and ensuing tsunami (hereafter simply the "earthquake and tsunami") has been ongoing on the Pacific coast in parallel with the decontamination work. This situation sometimes caused problems to secure necessary quantities of special equipment to use in the decontamination work. Specifically, it became necessary to improve efficiency and to make a comparative study between the cost and effectiveness of special equipment, which is generally expensive. Second, equipment leasing companies showed reluctance to enter into lease contracts, being concerned about contamination of equipment by radionuclides, especially in the early days of the decontamination work.

One decontamination business operator was able to over these problems by using materials and equipment for ordinary general civil engineering work and to use agricultural machinery owned by local farmers; for the latter the decontamination business operator employed the farmers under a contract and used their agricultural machines for decontamination work.

Example of general equipment	Mower, hand shovel, grass sickle, broom, bamboo rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags)), vehicles for transporting collected removed soil, etc. to the on-site storage location (truck, two-wheeled cart, etc.),ladder
Examples of equipment for cleaning with water	Hose, shower nozzle, high pressure water cleaner, brushes (scrub brush, brush for cleaning vehicles, brush for cleaning high places), scrubbing brushes (circular scrubber, steel wool brush, etc.), wire brushes, tools for pushing away water (broom, scraper, etc.), bucket, detergent, dustcloth, sponges, paper towels
Examples of equipment for cleaning metal surfaces	Brush, sandpaper, cloth, removing agents
Examples of equipment for cleaning wood surfaces	Brush, sandpaper, power sander, cloth, steam cleaner, water high pressure washer, tools for pushing away water (broom, scraper, etc.)
Examples of equipment for work in high places	Scaffold, mobile lift, aerial vehicle
Examples of equipment for scraping away	Grinding machine, equipment for scraping away, equipment needed to prevent dispersion (dust collector, curing mat)
Examples of equipment for covering the ground surface	Self-propelled surface compaction roller, plywood for surface compaction, sprinkling equipment

Figure 4-10 Examples of decontamination tools for work on structures like buildings[103].

[103]Source: Decontamination Guidelines (2nd Edition) (http://josen.env.go.jp/material/pdf/josen-gl-full_ver2_supplement1412.pdf) (Figure 4-11 has the same source.)

（3） Protective clothing, equipment and other items

The minimum suitable protective clothing, equipment and other items were used according to the Ionizing Radiation Ordinance for Decontamination and Guidelines of Ionizing Radiation Ordinance for Decontamination. By doing so, the amount of waste was limited by avoiding the excessive use of protective clothing, equipment and the like.

The Ionizing Radiation Ordinance for Decontamination and Guidelines of Ionizing Radiation Ordinance for Decontamination require that protective clothing, equipment and others be used depending on the radioactivity densities of the contaminated soil and the like, and the dust conditions (Table 4-8).

Table 4-8 Protective clothing, equipment and others[104]

	High contamination soil, etc. (exceeding 500 thousands Bq/kg)	Other than high contamination soil, etc. (less than 500 thousands Bq/kg)
High density dust work (exceeding 10mg/m3)	Entire body chemical protective suit over long-sleeved clothing (Tyvec etc.), rubber gloves (together with cotton gloves), rubber boots, dust protective mask with trapping efficiency above 95%	Long-sleeved clothing, cotton gloves, rubber boots, dust protective mask with trapping efficiency above 80%
Other than the above	Long-sleeved clothing, rubber gloves (together with cotton gloves), rubber boots, dust protective mask with trapping efficiency above 80%	Long-sleeved clothing, cotton gloves, rubber boots, dust protective mask with trapping efficiency above 80%

* Surgical masks, non-woven fabric masks and other practical masks also may be used when handling vegetation and leaf mold.

（4） Storage containers for removed soil and other wastes

Flexible containers and large sandbags of about 1m^3 capacity (dimensions: about 1.1 m in diameter by about 1.1 m in height) (hereinafter referred to as “flecon bags”) were mainly used as storage containers in the decontamination and related works in the Special Decontamination Areas ordered from the MOE. Durable materials were used for long-term storage (a few years) and for storing removed soil containing much water. Selection of containers was based on characteristics, weight, storage duration, etc. of the removed soil and other wastes. Examples of flecon bags include cloth-type containers (for one-time use) with a weather-resistant inner bag, running-type containers (for repeated use), and large weather-resistant sandbags with an inner bag (Figure 4-11).

Currently used are, as specified in the Common Specifications (7th Edition), those products which meet the specifications of “Flexible Containers Based on the Decontamination Guidleines” by the Japan Flexible Container Industries Association, the “Layer Stack Method Design and Construction Manual for Weather-resistant Large Sandbags” by the Public Works Research Center, and are certified by official test organizations, as meeting the performance standards required for materials and container bags.

[104]Source: Ionizing Radiation Ordinance for Decontamination and Guideline on Ionizing Radiation Ordinance for Decontamination (http://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000029897.html)

Type	Photograph	Characteristics
Flexible container (cloth-type)*1		• The assumption is that they will only be used once. • Not as good as the running-type in terms of weather resistance and waterproofness. • Some have improved weather resistance as a result of UV treatment and the like, while another type has improved waterproofness as a result of being lined with inner pouches and having an inner coating, etc.
Flexible container (running-type)*1		• The assumption is that they will be used by having soil repeatedly stored in and removed from them. • Outstanding weather resistance and waterproofness
Large sandbag	 *2	• Water permeable. • Some have improved weather resistance as a result of UV treatment and the like, while another type has improved waterproofness as a result of being lined with inner pouches, etc.

*1: Pursuant to JIS Z 1651.
*2: The photograph shows a weather resistant container.

Figure 4-11 Examples of flecon bags and large sandbags.

The Common Specifications stipulate that removed soil and other wastes generated in the decontamination work in the Special Decontamination Areas are to be stored in either of the following nine groups (i) to (ix).

- Combustibles:

    (i) Vegetation (pruned branches, fallen leaves, lawn grass, moss, weeds, litter layers, trimmed trees, roots, etc. Attached soil should be removed to the extent possible).
    (ii) Other combustible wastes (Tyvek coveralls, disposable work clothing, masks, filters, rubber gloves, paper, etc.)

- Incombustibles, mixtures:

    (iii) Soil and others (soil, gravel, small stones, etc. Vegetation should be removed to the extent possible.)
    (iv) Concrete and other materials (tiles, bricks, blocks, rocks, etc.)
    (v) Mixtures with asphalt
    (vi) Other incombustibles and mixtures (except dangerous objects, hazardous materials)

- Dangerous objects, hazardous materials

    (vii) Architectural material including asbestos
    (viii) Plaster boards
    (ix) Other dangerous objects, hazardous materials

The Common Specifications require that the tags attached to flexible containers and other similar containers be made of materials with corrosion resistance, weather resistance, good durability and not hazardous and the required information about contents, etc., should be machined into the tag surface so that it is legible for at least three years under the combined conditions of decontamination work, and transfer to and storage at temporary storage sites; finally the tags should be identified by color according to the individual contents.

Table 4-9 Correspondence between contents and tag colors[105].

	Color	Content
A	White	Soils, etc. (earth, small stone, gravel, etc.)
B	Green	Corruptive combustible material (pruning branch, fallen leaves, lawn, moss, weed, litter layer, trimmed tree, uprooting, etc.)
C	Yellow	Combustible material (Tyvec, waste clothe, mask, filter, rubber gloves, paper, etc.)
D	Blue	Incombustible (concrete, etc. (tile, bricks, block, rock, etc.), mixture with asphalt, sludge, etc.)
E	Black	Incinerated ash
F	Red	Dangerous article (Material including asbestos, soils polluted hazardous material)

There was a case in which one decontamination business operator developed a Quick Register (QR) code system and applied it for efficiently processing the information below as the decontamination work progressed:

- Read selectively necessary items and input dose data with a handy type input machine;
- Transfer the information to a small printer and issue the QR code; and
- Export the data to the decontamination information system in the format of a delivery.

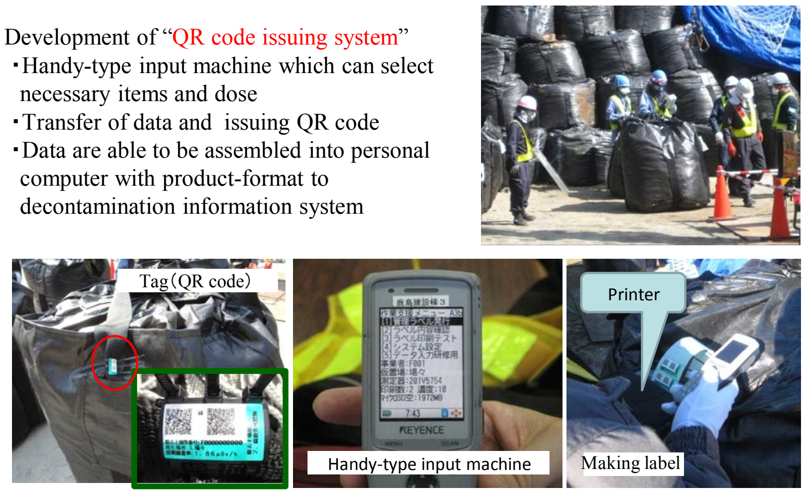

Figure 4-12 Examples of QR code issuing system[106].

(5) Issues associated with supervisors, skilled workers (with qualifications), and decontamination workers

Decontamination experts were quite limited among managers and employees (foremen and workers) of decontamination business operators. Also persons who were knowledgeable about radiation were limited. Quite a few workers had no field experience in civil engineering or construction work and they lacked knowledge about industrial health and safety practices, which was quite fundamental at such workplaces. The issue then was to provide education about basic work safety practices.

Some decontamination business operators had their own personnel educate the workers while the personnel themselves were learning about the topics, or the operators had the

[105]Source: Decontamination Project Common Specifications (7th Edition) (http://tohoku.env.go.jp/fukushima/to_2014/data/0410ba.pdf)
[106]Source: Kajima Corporation (Figure 4-14 has the same source.)

workers learn by actually doing the decontamination work.

To secure necessary numbers of decontamination workers with suitable qualifications, the rising market wage was an issue, too. This is because of the ongoing restoration and reconstruction work in parallel with the decontamination work on the Pacific coast from the damage by the earthquake and tsunami. In particular, the issue regarding decontamination workers was not only the big workforce required, but also the changing demand of workforce with the progress of decontamination work as illustrated in Figure 4-13. Some decontamination business operators, while emphasizing recruitment of local workers, tried also to acquire workers from prefectures outside Fukushima.

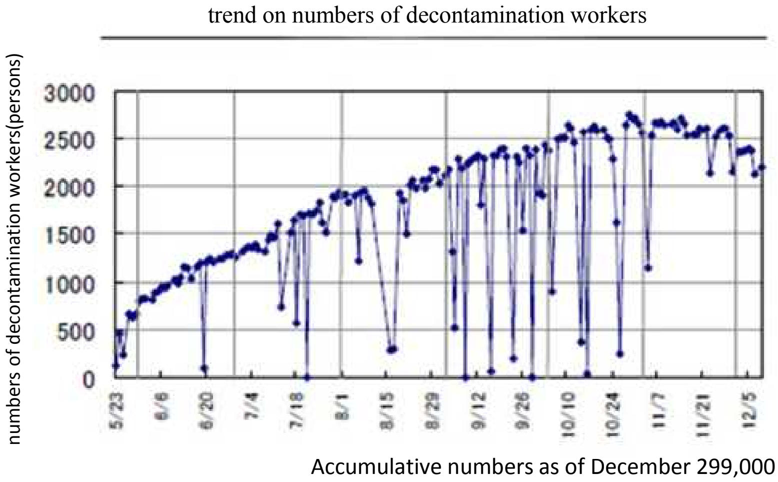

Figure 4-13 Monthly change of workforce (Example)[107].

[107]Source: Okumura Corporation (Figure 4-15 has the same source)

(6) Accommodation facilities for workers

The issue for a large number of the decontamination workers was to secure daily commuting means (limited available routes and subsequently, traffic jams) from outside the Special Decontamination Areas, since all the residents had been evacuated and all existing accommodation facilities and the like were not in service. Overnight stays are generally not allowed in the areas to which evacuation orders are being prepared to be lifted, but they were exceptionally allowed if needed for reconstruction. There was a case, in which accommodation facilities for workers were exceptionally built in the Special Decontamination Areasthrough coordination with the local municipality and the Nuclear Emergency Response Local Headquarters.

Some difficulties faced were as given below.

- Need to increase the capacity of accommodation facilities for increased number of workers subject to the work progress.
- Concerns of local residents about workers coming from outside and possible worsening of public morals (expressed as opposition to building the accommodation facilities).
- Opposition from the local residents when building an accommodation facility for those workers who were decontaminating a site different from their own municipality. Time loss by commuting over a long distance was another difficulty in this case.
- Traffic congestion along the route between the accommodation facility and the work site during commuting times.

To cope with these difficulties, the following measures were taken by some decontamination business operators.

- Making school buildings and public facilities, etc. the earliest decontamination targets so that they could be used as accommodation facilities close to the work site.
- Having local municipalities provide a piece of land in their possession to decontamination business operators for the purpose of building an accommodation facility for workers.
- Prioritizing contracts with local workers who can commute from their own residences.
- Implementing institutionalized patrols of accommodation facilities.
- Taking measures to mitigate the commuting burden by providing commuter buses, operating them on a time-shifted schedule (time-shifted duty hours of workers) and other means.

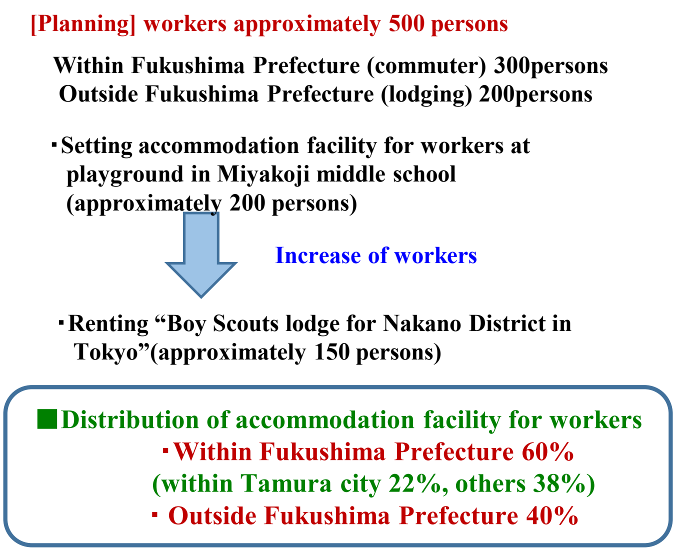

Figure 4-14 Example to secure accommodation facilities for workers (plan and result).

Figure 4-15 Example of an accommodation facility for about 350 workers.

(7) Processing of household wastes, foods, water, etc.

Special Decontamination Areas include the places damaged by the earthquake and tsunami. In such places, some of the infrastructures are still not available, including roads, water supply and sewerage systems, general waste treatment facilities, etc. and business activities such as retailing have been halted since the residents were evacuated.

In the usual situation, each business operator is responsible for disposing wastes produced by workers (lunch boxes and other garbage). However, general waste treatment facilities, industrial waste treatment facilities and sewage treatment facilities were out of service, having been damaged by the earthquake and tsunami and not restored. Neighboring treatment facilities had to bear the load instead, but their treatment capacities were exceeded. Consequently, the decontamination business operators were asked in the early stage to treat the garbage and sewage by themselves. In a later stage, the government, the ordering party, exchanged information with local treatment facilities, in which the amount of sewage and wastes was predicted together. Measures were jointly taken to coordinate the balance sheet of the volume to come from the decontamination work plan and the processing capacities of treatment facilities in order to avoid adverse impacts from the activity.

Regarding meals and water, an independent rest house was set near the working site of decontamination activities from the viewpoint of radiation protection. Workers were strongly instructed to stay inside the rest house while eating meals and drinking water, not outside on the decontamination site. If a rest house was not available, they were instructed to eat and drink inside a vehicle.

4.3. Acquisition of Residents' Consent

This section describes the efforts made in advance surveys, acquiring consent, and after-action reporting, and presents the challenges identified through these processes by the ordering party (MOE) and business operators for decontamination work in the Special Decontamination Areas.

4.3.1. Efforts Made by the Ordering Party (MOE)

In implementing decontamination and other related works, the MOE tried to acquire prior consent of stakeholders such as residential land owners (people who have the right to claim the authority to prevent the decontamination and other related works from being taken for the target objects to be decontaminated such as land, structures on it, or standing trees or other fixtures rooted on it) with regard to the details of said works.

In Tamura City, advance surveys and consent acquisition activities could start ahead of other municipalities. The MOE personnel involved themselves in the advance survey and consent acquiring initiatives. The knowledge and experience they obtained were applied and reflected in activities in other municipalities. Since the MOE personnel who could be allocated was limited, the advance surveys and consent acquisition were commissioned to private operators for cities other than Tamura City. The MOE personnel took the role to confirm the results of the commissioned work.

（1） Advance surveys

After collecting and organizing the relevant information on land, houses, etc., advance surveys of properties (field surveys) were performed prior to conducting the decontamination work.

1）Collecting and ordering information on land and houses

Stakeholders were identified, using such sources of information as real estate registers, land and house records, house drawings and land lot maps, and the relevant information was collected about land and houses by marking residential boundaries (on a land owner basis) and buildings onto maps and aerial photographs.

A great deal of effort was needed in solving the following issues for confirmation with the cooperation of local municipal personnel, local district officers, land planning unions, etc., in organizing the relevant information on land, houses, etc.

- Some house drawings were very old or did not exist.
- A particular stakeholder could have more than one piece of land and more than one house. It took time to consolidate registered owners to one name for identifying what properties were actually owned by that particular stakeholder.
- There were diverse cases with complicated relationship of rights, possibly because of inheritance: more than one owner had the right to one piece of land; registered information had not been revised after the death of stakeholder(s); a person or persons different from the registered owner(s) used and managed a piece of farmland for agricultural activities. In particular, it took much time to identify stakeholders and acquire their consent in a situation in which the stakeholders were not living at the site.

2）Property surveys prior to decontamination work

It was necessary to identify in the document of consent the target objects to be decontaminated by photos, drawings and other means. Therefore, decontamination business operators conducted radiation monitoring surveys and damage surveys of buildings as part of their advance property surveys (field surveys) ahead of the drafting of the document of consent prior to decontamination work.

Decontamination methods to choose depend on the target object to be decontaminated and, the materials and state of the object's surfaces. As part of the radiation monitoring survey, measurements were made at selected points which could represent each target object to be decontaminated in the survey area.

It was necessary to confirm with the stakeholders the status quo of buildings and other properties prior to conducting the decontamination work. Given that they might have been completely or partially destroyed, or partially damaged due to the earthquake and tsunami, the state of damage to each building was visually inspected by qualified architects or emergency risk assessment officers, and photo records were prepared for each building subject to decontamination.

Prior consent was needed to enter the private land for advance property surveys (field surveys) ahead of decontamination work and the surveys could be conducted only where it had been granted.

(2) Drafting the document of consent

Personnel of the MOE or a private business commissioned for acquisition of consent prepared the "Building Current Condition Diagram," which used photos to explain to each stakeholder the appearance of buildings and damage conditions, and the "Decontamination Plan," which showed the buildings and the scope of land subject to decontamination and the decontamination methods to be used.

Figure 4-16 Example Decontamination Plan[108].

(3) Arranging special considerations, visiting the site

Upon drafting the document of consent, the stakeholder(s) was (were) invited to the site,

[108] Source: "On-site explanation of the Decontamination Plan and request for understanding of implementation for decontamination work" (http://www.katsurao.org/uploaded/attachment/6.pdf) (Figure 4-17 to Figure 4-18 have the same source.)

where the drafted document of consent was explained and the scope of the decontamination work was checked against the actual property. The stakeholder(s) was (were) then consulted on any special conditions for decontamination, the items that they wanted to include in the living spaces for decontamination (e.g., shrines built by ancestors on a nearby hill, mountain streams, access paths thereto, etc.) and the items that they did not want to decontaminate (gardens with garden trees and moss that had important personal meanings to the stakeholder(s)). Once all these were arranged, they were appended as special conditions in the draft document of consent (if necessary, the contents in the draft document of consent were revised).

(4) Acquisition of consent

When the stakeholder(s) could confirm the contents of the "Building Current Condition Diagram" based on its explanation using photos, the appearance of the buildings and the damage conditions, they were asked to sign and affix their personal seal to the "Current Conditions Report" (Figure 4-17). Further, when the consent was obtained to implement decontamination work in line with the scope of the target buildings and land and the decontamination methods thereof set out in the "Decontamination Plan" (including special considerations), stakeholders were asked to sign and affix their personal seal to the "Decontamination Implementation Consent Form" (Figure 4-18).

Stakeholders were asked to sign and affix their personal seal to the consent forms at the site, but in some cases follow-ups were needed when they wished to consult with their family or neighbors. There were also cases, in which their consent could not be obtained due to dissatisfaction with decontamination methods or other reasons.

Figure 4-17 Example of Current Conditions Report.

Figure 4-18 Example of Decontamination Implementation Consent Form.

(5) Post-work reports

Upon completion of the decontamination work, a post-work report was made on the work results based on the decontamination implementation plan. Post-work radiation monitoring was carried out immediately after the work completion in order to prepare for checking afterward whether the decontamination effect was maintained. With this, the decontamination work was considered to have been completed, but radiation monitoring was carried out thereafter on an ongoing basis.

In the meantime, sometimes difficulties arose with stakeholders originating from gaps between their expectations and the realities of decontamination work. Basically, these gaps in understanding should be solved through resident briefings and the decontamination consent acquisition processes, but actually there were cases which could not be solved; radioactive cesium could not be completely removed due to the conditions of the land in use and the limitations of decontamination methods used, or complete recovery was not possible after topsoil removal of agricultural land or the felling of ornamental garden plants. The following are some typical examples of issues raised by stakeholders from these gaps in understanding.

- There were locations where radiation doses did not decrease even after the decontamination work had been done.
- Some areas were not decontaminated, which included steep slopes and the like.
- No decontamination work was done if radiation doses were low before the work.
- Trees and branches were not cut down.
- Tiles were not replaced with new ones.
- Decontamination work did not recover the land to the condition suitable for commercial agriculture use.
- Unwanted household goods were not removed as trash.
- Houses damaged by the earthquake and tsunami were left as they were being

contaminated by radioactive materials. They should have been dismantled and removed, since they could not be used.

If decontamination work were to be done beyond pre-defined standards at the request of particular stakeholders, such exceptional service could impact the implementation of the entire decontamination project in terms of the relationships with other stakeholders. Steps were taken for work supervisors themselves, not the decontamination workers, to listen to the stakeholders' claims, consult with MOE supervisors on decisions and leave a record of the decisions, in order to ensure consistent and rational decisions concerning the project as a whole.

4.3.2. Efforts Made by Decontamination Business Operators

Tamura City could undertake advance surveys and consent acquisition activities ahead of other municipalities, as described before. The MOE personnel involved themselves in these activities, and the knowledge and experience they obtained were then used and reflected in the work in other municipalities. In some other cases, private entities commissioned by the MOE carried out advance surveys, field surveys and consent acquisition activities prior to the decontamination work ordered by the MOE.

(1) Advance surveys

In some cases, private entities (e.g. entities having measurement technologies or IT/data processing technologies) carried out advance surveys upon consignment by the MOE, before decontamination work in the Special Decontamination Areas was started upon order of the MOE. In one example, the data relevant to land and houses were processed, using GIS technologies in the procedures shown below. By creating a database, the next steps of field surveys and preparation and distribution of the document of consent were carried out more efficiently.

- Creating ortho-images for the target area, with roads, coverings, vegetation, land and house outlines in a scale of 1/1,000.
- Assigning building management numbers for each building on housing maps.
- Creating residential boundaries (in units by land ownership) using ortho-images and lot number maps.
- Extracting the lot numbers of buildings from existing lot number maps, and matching them with housing tax master maps to compile building data and attribute data[109]

(2) Field (site) surveys

In some cases, private entities (e.g. entities having GIS technologies) implemented field (site) surveys, upon consignment by the MOE, before decontamination work in the Special Decontamination Areas was started upon order from the MOE .

Some entities used PDAs (personal digital assistants) equipped with GPS and input map information in advance into the PDAs so that on-site the survey workers could more efficiently input any additional information obtained as they conducted their field surveys[109].

(3) Consent acquisition activities

There were also cases where the MOE commissioned private businesses (for example, environment consulting companies) to conduct consent acquisition activities in parallel with the decontamination work ordered by the MOE[110].

Specifically, private business firms commissioned by the MOE conducted the following activities under the guidance and supervision of the MOE Fukushima Office for Environmental Restoration.

- Notifying stakeholders of the results of advance survey activities.
- Investigating views on methods for local briefings and other procedures in relation to consent acquisition.
- Arranging schedules for local briefings.
- Acquiring consent from stakeholders for decontamination work.

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[109]Source: Asia Air Survey website "Environmental Rehabilitation Assistance Efforts" (https://www.ajiko.co.jp/dl/pdf_tf2014/p12-15.pdf)

[110]Source: Namie Town "Request for Cooperation in Acquiring Consent for Kitatanashio Administrative District Decontamination Work" (http://www.town.namie.fukushima.jp/site/shinsai/20140501-01.html)

4.4. Communication with Local Residents and Local Municipalities

This section presents an overview of challenges, means for solving them, measures taken, etc. with regard to communication between the MOE, decontamination business operators, local residents, local governments, etc. in relation to the decontamination work ordered in the Special Decontamination Areas by the MOE.

4.4.1. Securing Temporary Storage Sites

Securing temporary storage sites involved a number of challenges and much time to settle, as it required the understanding of landowners and local residents in order to proceed. This was the same in Intensive Contamination Survey Areas as it was in Special Decontamination Areas. The following challenges were encountered in securing temporary storage sites.

- Questions over why TEPCO or the National Government did not receive soil and other things removed.
- Concerns over the safety of temporary storage sites.
- Concerns about the possibility that the temporary storage sites would end up being used as disposal sites without such an agreement having been finalized.
- Doubts that even if a temporary storage site was necessary, it would be used for storing soil removed from other areas, too.

The MOE investigated the feasibility and coordinated the use of state-owned land for temporary storage sites, and there were cases in which national forests were used as temporary storage sites. But in many cases, that was not practical. Many state-owned forests are designated by the Forest Act as forest reserves for conservation. In order to use this land as a temporary storage site, relevant documents describing the state of trees and the current state of the forest would have to be examined and necessary procedures would have to be taken to remove the land from designated forest reserves for conservation. Such procedures needed a great deal of time and cooperation between relevant organizations. Furthermore, since the state-owned forests are generally mountainous, construction work was needed to flatten the land and new access roads needed to be developed and improved in some cases. It took a very long time to prepare for use of a state-owned forest as a temporary storage site. Furthermore, much of the secured land was sloped, resulting in less area available for storage. In other cases, no sufficient place other than the constructed temporary storage site was available for treating trees felled during construction and cut vegetation. Thus, the available area for storing was reduced.

4.4.2. Launching of the “Decontamination Dial 110 (Hotline)” to Receive Information about Questionable Decontamination Work

A contact point has been established to receive information by telephone or online from local residents upon witnessing decontamination work that they suspected to be inappropriate (hereafter refferd to as the “Decontamination Dial 110 (Hotline)”).

The MOE checks the information received, issues cautions to decontamination business operators if the information is correct, and provides explanation on handling of the matter on its homepage.

4.4.3. Efforts Made by Decontamination Business Operators

The following issues were encountered in communication between decontamination business operators and local residents or local governments in conducting decontamination work in the Special Decontamination Areas ordered by the MOE.

- It was important not only to reduce air dose rates in the living spaces by decontamination work, but also to mitigate or remove the concerns of residents through sincere risk communication.
- There were many occasions where it was impossible to move forward unless the cooperation of local residents and local governments was available.
- People could not be sure how much radiation dose rates would drop under the MOE decontamination specifications, because there were no specific target values (standards) for radiation dose rates after decontamination.
- There were requests not related to decontamination made at the time of site visits prior to the decontamination start.
- Residents could not be present on the decontamination site when the decontamination work was ongoing. It was thus important for decontamination business operators to be trusted to carry out the items properly as agreed in advance at the time of site visits (no improper decontamination work).
- Reluctance of owners to let construction companies from outside of the area conduct decontamination work.
- Indefinite terms for operating the temporary storage sites under unclear site conditions.
- Mass media and other news sources did not necessarily convey a complete picture of decontamination activities, or the detailed considerations of decontamination business operators when dealing with the local community.

In response, efforts as described below have been taken by decontamination business operators (Figures 4-19 to 4-28).

- Pursuing residents' understanding of the decontamination specifications through site visits prior to the decontamination work start. MOE personnel joined the advance site visits, and sincerely explained to them what could be done and what could not be done.
- Presenting relevant information on homepages and in town papers jointly published in cooperation with the town staff, as part of information disclosure on work status and progress; these presentations were done with the consent of the ordering party.
- Supporting local checks by residents (e.g., decontamination workers carried elderly residents to site checks).
- Opening resident consultation windows and call centers for decontamination work matters, and sincerely responding to requests and questions from residents.
- Arranging site visit tours of decontamination work in each district of a town where all townspeople had evacuated.
- Providing a "common room (chatting room)" and "public restroom for townspeople"who returned home on a temporary basis to the evacuation area.
- Responding sincerely to residents who came to observe the work upon request and permission.
- Eliminating anxieties of residents by making the staff visible and accessible.
- Communicating on a regular basis, building a relationship of trust through a build-up from small things.
- Volunteering to remove snow for home-bound elderly people in areas with heavy snowfalls.
- Holding social gatherings such as rice cake making or golf tournaments for residents living in temporary housing.
- Participating in, supporting and sponsoring events held in the area.
- Conducting "blue light" (voluntary) security patrols.
- Conducting patrols with safety patrol vehicles (including checks of litter), and patrolling villages and residences.
- Installing traffic safety banners at dangerous curves and narrow roads as traffic safety measures.

- Decorating fences enclosing temporary storage sites with photos or having high school students draw pictures in order to improve the image of the temporary storage sites.
- Installing banners on roads in the decontamination work area, indicating that the decontamination work was being carried out.

Figure 4-19 Removing concerns by face-to-face communication with responsible staff[111].

Figure 4-20 Goodwill exchange with local residents (example) [112].

Figure 4-21 Call center (example)[113].

Figure 4-22 A town paper jointly published with the town staff (example).

Figure 4-23 Homepage (example).

[111]Source: Taisei Corporation
[112]Source: Obayashi-Gumi Corporation
[113]Source: Maeda Corporation (Figure 4-22 to Figure 4-24 have the same source.)

・Institutionalizing a dedicated safety management system and patrol activities
・Institutionalizing a dedicated safety management system with executive class members of 3 JVs for proper safety and decontamination works
・Daily patrols by the system members
・Regular patrols by the personnel of head office and branch offices

【Flow of safety patrols by the system members】

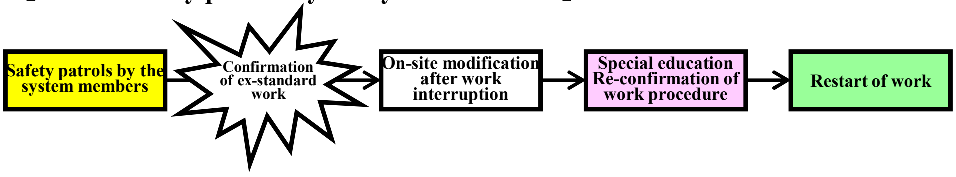

Figure 4-24 Dedicated safety management system (example).

A"Blue light" security patrol car

Departure for security patrol

Security patrol by the personnel including former Fukushima Prefectural Police Department personnel as key members (Appreciation prize awarded on December 28, 2012 and December 27, 2013)

Figure 4-25 "Blue light" (voluntary) security patrol (example)[114].

- Monthly security patrol (1st and 3rd Friday)
- Area to patrol: Prefectural and national highways, wide area agricultural roads

In-village patrol
- Area to patrol: Katsurao village (crushing facilities and others)
- Frequency: Sunday, all day long

Residence patrol
- Dormitory for decontamination workers to patrol: 4 places
- Frequency: Monday to Sunday, unscheduled patrol twice a day, from evening to mid-night at dormitories

Security patrol car

Litter checks

Patrol route in a village

Security monitoring at a dormitory for decontamination workers

Figure 4-26 Safety patrol (example)[115].

[114]Source: Taisei Corporation and Maeda Corporation
[115]Source: Okumura-Gumi Corporation (Figure 4-27 has the same source)

A banner for safe driving (in Katsurao village)
- 21 banners at 9 places on 3 nearby highways
- 30 banners at 14 locations on village roads/forest roads

- Traffic safety moral-up campaign: Monday to Wednesday of the first week every month
- Traffic safety campaign week: attendance at the patrol departure of the Tamura Police Station (September 20)
- Traffic safety flyer (September 27)

Traffic safety banners in poor-sighted curves (Shikiihata district)

Traffic safety banners in narrow roads (Oozasa district)

Traffic safety moral-up campaign

Traffic safety campaign week: patrol departure

Figure 4-27 Traffic safety banners and activities to encourage good driving manners (example).

Paintings on loading and unloading places for the temporary storage site
Paintings on the fences for the sandbags working place for volume reduction as part of decoration

Figure 4-28 Decorating fences surrounding temporary storage sites with colorful photos and drawings (example)[116].

4.4.4. Provision of Wide-ranging Information to Local Residents, and related activities

In moving forward with decontamination projects in the Intensive Contamination Survey Areas, in addition to the Special Decontamination Areas, it was absolutely necessary to respond to all kinds of concerns and frustrations of local residents about the decontamination methods and work, and concerns about safety and other issues with regard to establishing temporary storage sites. The MOE cooperated with Fukushima Prefecture and set up the "Decontamination Information Plaza" in January 2012, near Fukushima Station, in order to disseminate relevant information on decontamination and radiation and to provide an operation base for experts to carry out informational activities. The Decontamination Information Plaza has been promoting communication with local communities by providing various exhibits and pamphlets, arranging workshops or opinion exchange meetings, dispatching registered experts to local governments or communities upon request, or responding to consultations from the local residents. The MOE has also made efforts to facilitate people's understanding through its website (Decontamination Information Site (in Japanese): http://osen.env.go.jp) and a call center, and through information dissemination via the mass media.

In JFY2014, the MOE joined in an advertisement project "Thanks, Helmet" arranged by the "ONE Fukushima" program by eight local mass media entities (newspapers, TVs and radio broadcasting) in Fukushima Prefectre. This project was planned in order to eliminate

[116]Source: Maeda Corporation

negative image toward the decontamination work and decontamination workers, and to facilitate the understanding of local residents toward decontamination. In the project, "Thanks messages" being addressed to decontamination workers were solicited, mainly from evacuees of Futaba District (Gun) and school pupils in Koriyama City (elementary schools and junior high schools). The messasges expressed and conveyed their feelings of thanks and support to the decontamination workers. Those messages were distributed to the decontamination workers in a form of stickers to be attached to their helmets (more than 1,000 messages were collected and more than 3,000 decontamination workers received them). Many decontamination workers expressed their willingness to return their messages. They responded in the form of sending large poetry cards with their return thanks messages, donating planters, volunteer service of paining playing equipment, etc. to the schools. The activities were widely disseminated through mass media in the prefecture. The project could facilitate motivating the decontamination workers and raising their morales through heart-warming communication with local residents and children.

4.5. Project Management Executed by Decontamination Business Operators

Decontamination business operators encountered various issues in implementing decontamination and related works in the Special Decontamination Areas, upon orders being placed by the MOE. The problem solving approaches taken by the decontamination business operators and the ideas behind them are outlined below.

4.5.1. Schedule Control

There are snowbound areas in winter season in the Special Decontamination Areas. In such areas, no decontamination works is scheduled during snowbound months because there are special difficulties as listed below.

- Big uncertainties cannot be avoided in air dose and surface dose density measurements in snow-covered environment.
- The quality of decontamination work may drop due to difficulty in confirming the effectiveness of the work results in a snow environment.
- The efficiency of surface soil removal work, weeding or other tasks drops because weeds are knocked down by the snow.
- Snow may attach to the soil and other things removed, and the added moisture causes an increase in weight and volume.
- Snow and ice melt when the temperature increases in temporary storage sites and the water content oozes out and accumulates in the sites. Volume changes of the filled bags at the sites will occur and may damage the cover sheets and other things.
- Transportation by trucks on the slopes to the temporary storage sites in mountainous or hilly locations becomes impossible, and removed materials, which should be transferred to the temporary storage sites, must be left in the work areas.

Also when it rains more than a preset amount, the decontamination work is halted, because rainfall causes uncertainties in air dose and surface dose density measurements; removed materials may be carried away or swell and increase in weight; water contents ooze out and accumulate in the temporary storage sites; rainwater accumulates in the temporary storage sites once the temporary cover sheets are removed for bringing in new waste materials, etc.

The project schedule had to be managed in consideration of those days when decontamination work could not be done due to adverse weather conditions. Beside weather conditions, following issues arose for schedule control.

- Decontamination work should be completed the soonest in the living spaces.
- There would be delays in obtaining residents' consent and securing temporary storage sites.

- Responses would need to be made to requests to complete decontamination of shrines and graveyards before mid-August for O-bon.

Examples of measures to meet these conditions by one decontamination business operator were:

- Intensive deployment of large workforce.
- Workforce control depending on the decontamination work progress.
- Schedule control subject to the request of the local communities.

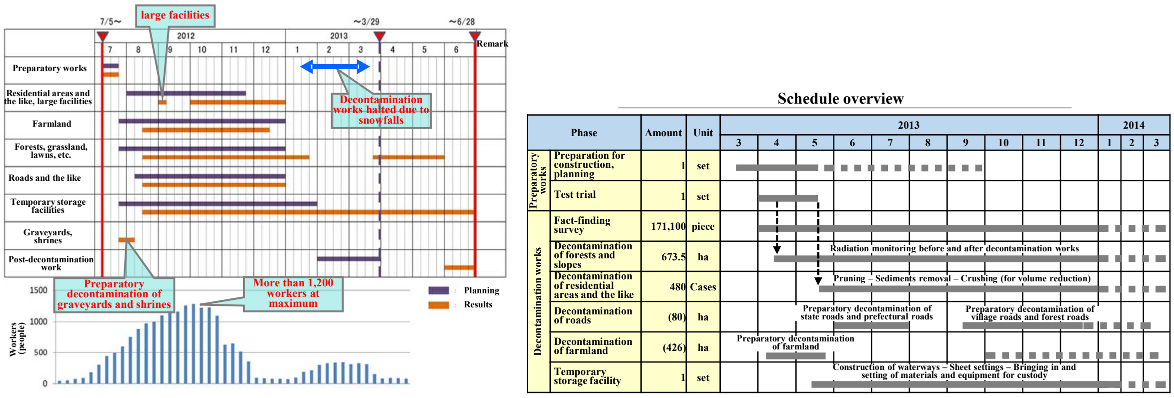

Figure 4-29 Example of decontamination schedule[117].

4.5.2. Operational Framework for Decontamination Work

As was mentioned briefly in Chapter 4.2.4 (5), the issues encountered in the decontamination operation include:

- Large workforce of thousands (1,000 to 6,000) needed at one work site[118].
- Workforce management depended strongly upon the schedule and progress of decontamination works.
- Rapid turnover of workers.
- Qualities of workers.
- Obtaining the radiation exposure history and health conditions of workers upon recruiting them.

For instance, there was a case in which the daily maximum number of workers needed was 1,200, far above the planned workforce at the beginning as shown in Figure 4-31, in the decontamination work for an area with about 120 houses in a residential area, about 1,300,000m^2 of farmland, about 1,900,000m^2 of forests and about 96 km of roads. In such circumstances, the decontamination business operator took such measures as follows.

- Promoting recruitment of local workers.
- Employing local farmers (utilizing agricultural machinery already in their possession).
- Recruiting workers nationwide.
- Providing periodic and continuing education of new workers for the field work.
- Providing full medical check-ups at designated hospitals with costs paid by the primary contractor.

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[117]Source: Kajima Corporation and Okumura-gumi Corporation (Table 4-30 has the same source.)

[118] Examples: About 2,700 workers were needed at the peak in a site of about 17,000,000 m^2 for decontamination work (about 470 houses as well as farmland, roads and other items were included), while about 3,000 workers were needed in a site of about 14,000,000 m^2 (including about 1,270 houses) or about 2,200 workers in a site of about 8,300,000 m^2 (including about 1,180 houses).

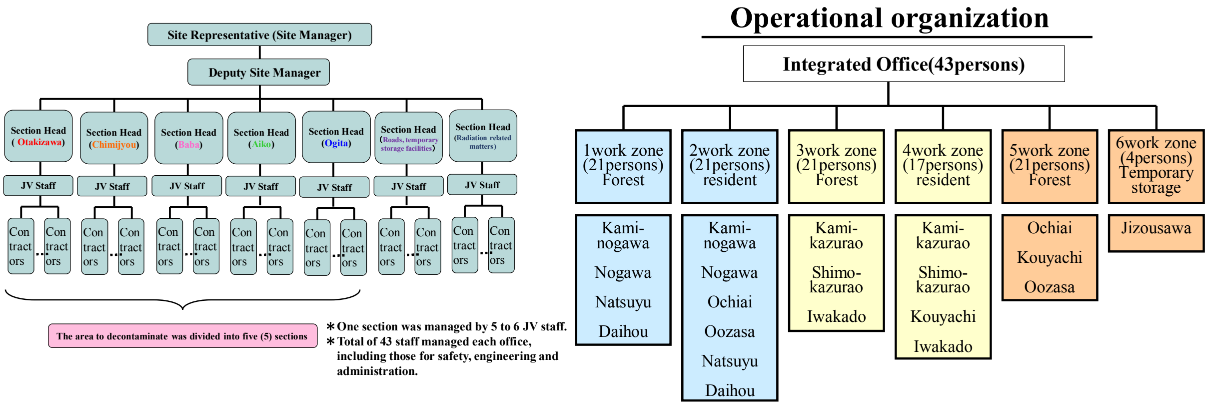

Figure 4-30 Example of operational framework for decontamination work.

[Planned] total workforce: about 70,000
The site divided into five (5) sections.
About 100 workers per each of five sections,
totaling about 500 workers at daily maximum

- **Difference in workload is outstanding in forests and others**
- **Small transfer to vehicles for transport (hand carry, by machines)**
- **To keep the goal of "completing decontamination by the yearend"**

[Record] total workforce: about 120,000
The site divided into five (5) sections.
Daily maximum of 1,200 workers deployed for the site.

Figure 4-31 Example of recruiting and deploying workers (plan and result)[119].

Figure 4-32 Example of employing local farmers[120].

[119]Source: Kajima Corporation
[120]Source: Obayashi Corporation

4.5.3. Sharing of Information and Safety Precautions

One issue was how the relevant information and safety precautions could be shared completely between many contractors and the large number of workers involved, not only with the primary contractors (some of which were Joint Ventures (JVs)) and their personnel. The complete sharing of relevant information between relevant organizations was also a challenging issue. An example to solve such issues can be found in the following case for one decontamination business operator.

- Information sharing meetings were periodically held with relevant organizations concerning the decontamination work, its progress and other relevant information. Participating organizations were: the MOE Fukushima Office for Environmental Restoration, local municipalities, the Labour Standards Inspection Office, police and fire stations, and the primary contractors (JVs).
- Plenary or separate morning assemblies and daytime assemblies were regularly held for thorough dissemination and sharing of information at different levels between the primary contractors (JVs), subcontractors and individual work sections.

Progress review meetings

The project progress was regularly checked and relevant information was shared between the Fukushima Office for Environmental Restoration, Naraha Town, the Tomioka Labour Standards Inspection Office, Futaba Police Station, and the relevant decontamination business operators.

Figure 4-33 Photo taken at a project review meeting[121].

[121]Source: Maeda Corporation

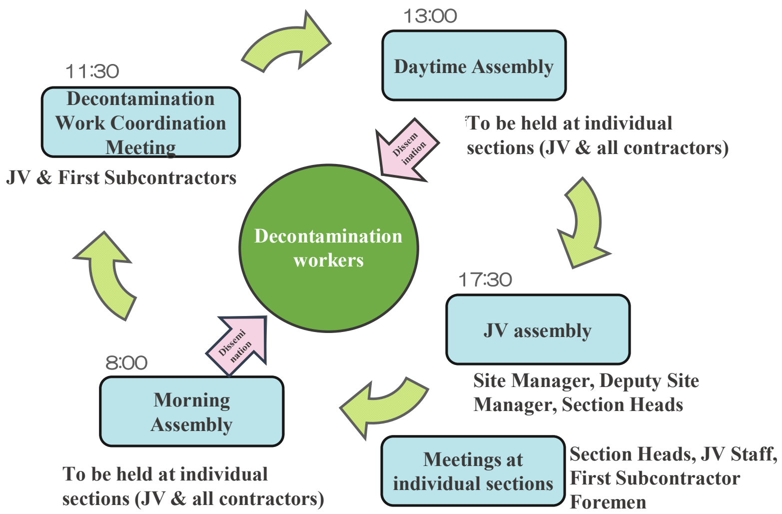

Figure 4-34 Example flowchart of dissemination and sharing of information and safety precautions[122].

Some decontamination business operators prepared specific work procedures for decontamination workers to refer to during actual work. These work procedures elaborated on the decontamination methods presented in the Decontamination Guidelines, technical specifications and other relevant documents. The work procedures also provided information concerning, not only the decontamination skills, but also the supervising responsibilities of decontamination business operators, application methods of materials and equipment of decontamination work, safety checks and precautions to be taken, and responses to be taken in an emergency or unusual situations, etc.

These work procedures are updated based on experience and knowhow obtained from the actual decontamination work. When updated, actions are taken to disseminate the new information to the decontamination workers on the job (for instance, holding a meeting for disseminating and sharing the information).

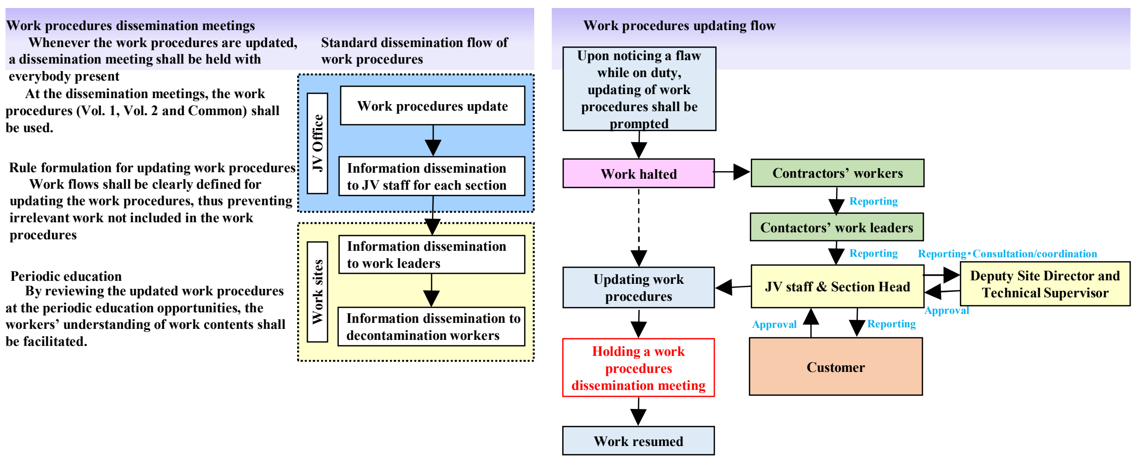

Figure 4-35 Example flowchart of information dissemination and sharing of updated work procedures[123].

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[122]Source: Kajima Corporation
[123]Source: Maeda Corporation

4.5.4. Hiring and Separation Management of Workers

In the hiring and separation management (upon recruitment and upon separation) of workers, the decontamination workers are required by law, as mentioned earlier, to receive internal exposure measurement for radiation protection and exposure control before and after the employment by the decontamination business operators. For the internal exposure measurement, the whole body counters (WBCs) installed by the MOE were available at no charge to the workers and decontamination business operators.

Newly employed workers are to receive basic and special education upon beginning the decontamination work, including:

- To recieve internal exposure measurements by a WBC.
- To receive eduction about decontamination and related works by using educational slides, DVDs and the like.
- To receive education on and learn the matters concerning safety principles, safety rules and the like through lectures given by JV safety personnel at the site office.
- To learn specific work procedures through attending the work procedures dissemination meetings held at the site office, assembly halls, or the like.

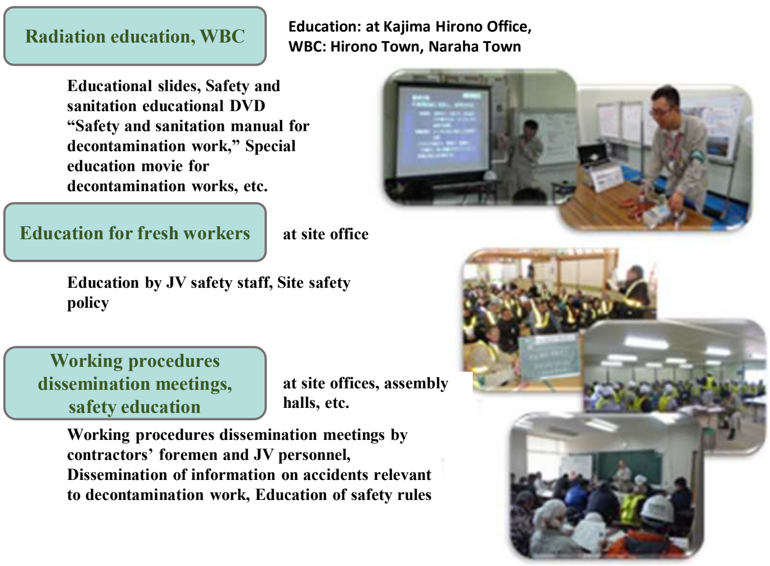


Figure 4-36 Example flowchart of education flow for decontamination workers[124].

4.5.5. Protection from wildlife

Concerns about protecting from wildlife also existed. There were cases in which decontamination business operators removed beehives and had to prepare protective equipment and medications in advance, or they consulted with the municipal offices for how to deal with livestock such as cows that had been abandoned by owners when evacuation orders were given.

[124]Source: Kajima Corporation

4.6. Radiation Protection Measures

4.6.1. Ionizing Radiation Ordinance for Decontamination

As mentioned earlier, the Ministry of Health, Labour and Welfare (MHLW) issued the "Guidelines on Prevention of Radiation Hazards to Workers Engaged in Decontamination and Related Works" on December 22, 2011, as the measures required to ensure the safety of workers, in combination with the Ionizing Radiation Ordinance for Decontamination (The Guidelines were partly amended on June 15, 2012.). The Guidelines specify the following: personnel subject to exposure dose control; methods of control administration of exposure dose measured; measures to decrease exposure dose; measures to prevent contamination from spreading; measures to prevent internal exposures; education for workers; measures to ensure health; and safety and sanitation management system.[125]

In the decontamination work, radiation protection measures are provided to the decontamination workers pursuant to the Ionizing Radiation Ordinance for Decontamination. The MOE arranged the following measures in order to ensure that decontamination workers and operators observed those measures set in the Ionizing Radiation Ordinance for Decontamination.

- Holding workshops for potential decontamination workers.
- Stipulating in the decontamination order contract the condition that the decontamination business operators must observe the Ionizing Radiation Ordinance for Decontamination.
- Preparing methods to estimate necessary expenditures and reserve budgets for necessary equipment for radiation protection.
- Requiring decontamination business operators to include relevant descriptions concerning technological concepts of workers' radiation protection in the decontamination plan documents when applying for National Government work under direct jurisdiction of the MOE.

In the meantime, the decontamination business operators took the following measures for radiation protection.

- When designating a new decontamination work area, the air dose was measured before workers engaged in the decontamination work. If micro hot spots were recognized, they were clearly so indicated by markings or setting fences, or the access to the hot spots was controlled.
- Where the air dose rate exceeded the level to cause 50 mSv/y, the workers were instructed to wear full-face masks, protective clothing and other items in order to prevent dust containing radioactive materials from attaching to the workers.
- In work areas, where the air dose rate was below the level to cause 50 mSv/y, too, workers were instructed to wear half-face masks.

4.6.2. Surface Contamination Inspection (Screening)

The Ionizing Radiation Ordinance for Decontamination obligates decontamination business operators to conduct surface contamination inspections (screening) in order to prevent contaminants containing radioactive nuclides from being brought out from the work areas.

The difficulty in the actual screening operation was to conduct the screening inspections for a large number of workers, particularly at some specific time periods (lunch time, at the end of the day, etc.). There was a case in which the screening process was automated for better efficiency and worker-power saving at the times for breaks, lunch or the end of the day.

In measuring the surface contamination densities, as mentioned in 4.1.3 (5) 1), it is required to use surface radiation contamination survey meters which meet the performance

[125]Source: Ministry of Health, Labour and Welfare (MHLW), Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Radiation Works (June 15, 2012)

requirements and other conditions specified in JIS Z 4329 and the measured data by such survey meters are to be recorded as the counting rate (cpm). In reality, however, the data varied among measurement devices depending on their respective measurement efficiencies and areas of measurement.

Figure 4-37 Photos of workers undergoing automatic screening[126].

4.7. Education and Health Care for Decontamination Workers

4.7.1. Education of Workers

Decontamination work does not usually require ordinary workers to be highly experienced or have special skills; although it is true that only certified workers with particular qualifications or skills may be engaged in operating heavy machinery for carrying heavy objects or scraping soil off, transferring wastes, etc., or for tasks done at high places using aerial lifting equipment, such as needed in washing and wiping processes for roofs and others.

But even ordinary workers are required to understand the basics of decontamination and follow the pre-determined working procedures. Otherwise, the expected decontamination effects may not be obtained, the decontamination effects may even drop, the amount of materials to remove may increase or even trouble may take place with the local residents. Furthermore, it was foreseen that most of these ordinary workers had no prior experience in decontamination and lacked knowledge or experience in radiation protection.

Before the Great East Japan Earthquake, ordinary citizens in Japan did not usually have knowledge of radiation nor were they familiar with decontamination. It was impossible to secure a large workforce consisting of workers who had had experience and knowledge about radiation and decontamination.

Certain qualities are also required of decontamination workers, not only their availability in large numbers. Education was the only way to foster knowledge about decontamination and promote the necessary qualities among the workers. Before commencing decontamination works, the decontamination business operators provided new workers with basic and special education pursuant to the Ionizing Radiation Ordinance for Decontamination. In addition, workshops, training and other activities were periodically held about safety as well as daily morning activities on risk potential prediction and mutual checks of protective equipment before commencing the day's work. Other activities included collection of success stories and failures in order to develop the workers in broad areas. The decontamination business operators promoted special education smoothly and easily using educational movies on the YouTube produced by the MHLW for decontamination and related works. Workshops on

[126]Source: Kajima Corporation

decontamination work arranged by the Fukushima Prefectural Government and MOE for the workers and work leaders also facilitated the education activities done by the decontamination business operators.

Education activities should be repeated. Decontamination methods and knowhow of site works are improved day by day. Successful experiences as well as failures, near-miss cases and other experiences from work sites were used for ensuring safety through periodic education opportunities after decontamination work was started by new workers. A system was developed that allowed supervisory personnel to check on-site that each worker took notes when attending the education activities, submitted reports after workshops and recorded their attendance at the educational programs on their worker ID cards.

The following are examples of educational programs conducted for decontamination workers[127].

[127]Source: Maeda Corporation (Figure 4-38 to Figure 4-44 have the same source.)

(1) Educational programs upon beginning the jobs

1) Safety education for newly employed workers

Safety education for newly employed workers included: explanation of the jobs to do using flowcharts, safety policies at the work place; basic rules of safety and sanitation; activities relevant to safety and sanitation; safety rules when on duty; instruction to be checked using the WBC; and items to consider with respect to residents.

	Program	Key contents
1	Confirmation of employment contract	Confirmation of the company to belong to, minimum wages, special duty allowance, medical checks
2	Outline of the jobs	Explanation of an outline of jobs to do
3	Safety policies at the working place	Explanation of safety policies at the working place Prevention of falling down Prevention of minor collision between men and heavy machinery Prevention of minor collision between men and mowers Radiation and health cares Other related topics
4	Basic rules of safety and sanitation	Explanation of basic rules of safety and sanitation Consideration to give to local residents Dose measurements and contamination inspections Safety equipment Practice to carry Identification Card and armband Information on work plans and work procedures Smoking, eating and drinking Responses to take when injured Traffic rules
5	Activities relevant to safety and sanitation	Explanation of activities relevant to safety and sanitation
6	Tidiness and order	Explanation of the rules to keep working places tidy and in order
7	Risk potential prediction "KY"	Explanation of the process to predict risk potential for sharing KY: an acronym of "Risk potential prediction" in Japanese)
8	Harmonization with the community	Explanation of consideration to give to local residents
9	Safety rules on duty	Explanation of "22 musts in safety rules" which assembled the cases experienced and the results found during patrol for each of selected cases
10	Instruction to receive WBC checks	Instruction of receiving the WBC check and considerations to give.

Figure 4-38 Example program of safety education for newly employed workers.

2) Safety and work education

Safety and work education is conducted by: (i) clarifying concrete work procedures and key items to ensure safety at the workplace; and (ii) providing a safety manual, which collected cases of experience and results found during patrols and compiling the information into “mandatory workplace safety rules.”

2. Working policy at workplace

Provide sufficient qualities to meet expectations of the customer and local communities in reliability, credibility and satisfaction by the work with due consideration to the environment. The work is based on the concept of “Quality first” and “Customer first” with the fundamental philosophy of “Grasp the customer’s credit by the work in good quality.”

Achieve zero disaster over the whole period of work by upgrading motivation of the personnel and workers toward safety

Key execution items for safety at the workplace

1. Prevention of falling down

- **To secure the safe working floor and to wear a safety belt and fall arresting devices/equipment for a fixed rope (Brand name Rolip, for instance) when working at an elevated place.**
- **To fix the ladder and to prohibit a stepladder**

2. Prevention of minor collision between men and heavy machinery

- **To designate the “Keep out” zone around the machine operation area before commencing the work**
- **To arrange a traffic controller and a guard**

3. Prevention of minor collision between men and mowers

- **To keep out of the dangerous zone (5m from the mower, 15m between mowers)**
- **Mutual calls of attention**

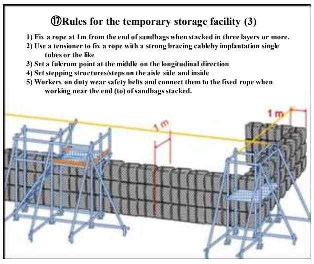
4. Radiation control and health care

- **To wear dust masks**
- **To practice gargling, hand washing**
- **To practice routine conditioning of body rhythm**

5. Not to give any concerns to the local people

Figure 4-39 Example chart of work policy posted at a workplace.

Safety rules for decontamination	
①Rules for drags for cart wheels	⑪Rules for scaffold elevators (1)
②Rules for construction vehicles (1)	⑫Rules for scaffold elevators (2)
③Rules for construction vehicles (2)	⑬Rules for using stepladders
④Rules for working with heavy machinery	⑭Rules for using roof Rolip and fixed ropes (1) (note) Rolip (a brand name of fall arresting device/system for a fixed rope)
⑤Rules for access to heavy machinery	⑮Rules for using roof Rolip and fixed ropes (2)
⑥Rules for the temporary storage facility and others	⑯Rules for water supply
⑦Rules for unifying wireless (voiced) call signs	⑰Rules for the temporary storage facility
⑧Rules for working shoes	⑱Rules for garbage trucks
⑨Rules for using knives	⑲Rules for seat belts when using construction machinery of vehicle type
⑩Rules for using mowers	⑳Rules for iron plate floors for cranes



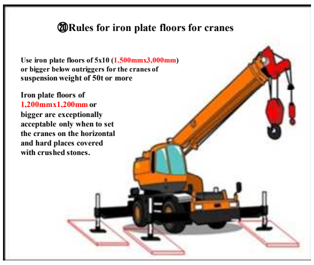


Figure 4-40 Example chart of safety rules for decontamination work.

3) Dissemination of information on work plans and work procedures

Work procedures are based on manuals for individual tasks and disseminated at meetings for that purpose.

4) Proper decontamination education

Education for items to note in proper decontamination is conducted at the start of a new job as well as at the time of regular safety education.

5) On-site education

For better understanding by workers, practical training is implemented on-site.

Figure 4-41 Photo of workers getting practical training at a work site.

6) Other related matters

Special education for decontamination work, which is legally compulsory, is conducted based on the "Materials for Special Education on Decontamination and Related Works" (Compiled by the Health Measures Office for Ionizing Radiation Workers, MHLW), separate from the education for newly employed workers. Theoretically, respective contractors should provide such education to their workers, but the primary contractors (JVs) directly provided it to all workers as their responsibility.

Newly employed workers wear a special band on their helmets for the first week of work for easier identification; and responsible personnel and work leaders promote continuous education and training.

Figure 4-42 Photo showing a newly employed worker wearing the special helmet band for easier identification.

(2) Periodic safety education program

Through providing periodic safety education opportunities, workers are reminded repeatedly about safety-related items and a safety mindset is strengthened by repeating the items to note, checking seasonal concerns (e.g., freezing in winter) and exchanging opinions on safety among workers.

Safety Education (January)

① Hazard cases of other companies, other locations, etc.
② "Let's find risk potential I" (Text by the Head Office, Maeda Corporation)
③ Safety DVD "Six legal obligations which nobody can overlook"
④ "Let's find risk potential II" (Text by the Head Office, Maeda Corporation)
⑤ Coffee break
⑥ Reminding the safety rules at the working place
⑦ About proper decontamination
⑧ Wages are received appropriately?
⑨ Let's drive safely this month
⑩ Prevention of radiation hazards

Maeda & Kounoike JV
(Additional responses to decontamination and related works)
(12:00 to 16:00 on January 23 and 24)

Figure 4-43 Example of a periodic safety education program.

Issues in providing education for workers included the following.

- Among managers and other employees on practical level (foremen, workers) of the decontamination business operators, there were few decontamination experts who could be instructors. There were also few persons who were knowledgeable about radiation and could be instructors.
- Quite a few workers had no field experience in civil engineering or construction work. Education on basic safety management, which is quite common at such work places, was also needed.
- Safety education of workers was especially important, because the work environment could not be simplified or made uniform due to the size and diversity of the work areas, for instance, house roofs, forests, slopes, roadside embankments, etc.
- A large number of workers had to be educated.

To cope with such difficulties, the following efforts were made by decontamination business operators.

- The decontamination business operators' personnel were engaged in educating workers while learning themselves.
- Education was conducted every day to a group of about 100 workers.
- Engagement of the decontamination business operators' personnel themselves in decontamination work functioned as an effective education system.
- Merit awards were given to conscientious workers.
- Video films or other illustrated materials were used for facilitating easy learning.
- Group leader training was practiced as the best model group. This training facilitated decreased quality differences among groups and improved skills of the leaders.
- Periodic meetings were organized to exchange opinions between group leaders.
- Periodic study meetings were organized for workers.
- Patrols and inspections were made by the quality manager and model group leaders.

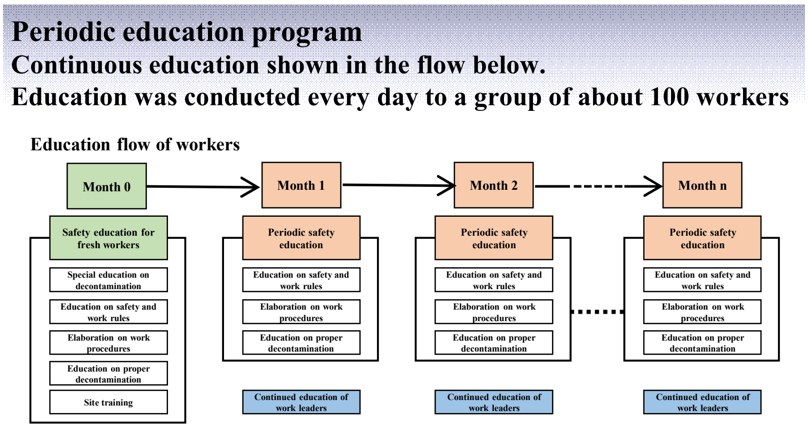


Figure 4-44 Example flowcharts of educational programs for decontamination workers.

◆ **Education by using video films and illustrations for easy learning**

Education is provided to all workers whenever fresh workers join, or work contents or working areas are changed, by using video films or illustrations which elaborate on work procedures in an easily understandable manner. Decontamination procedures are well disseminated to the workers because the materials are compiled in an easily understandable manner.

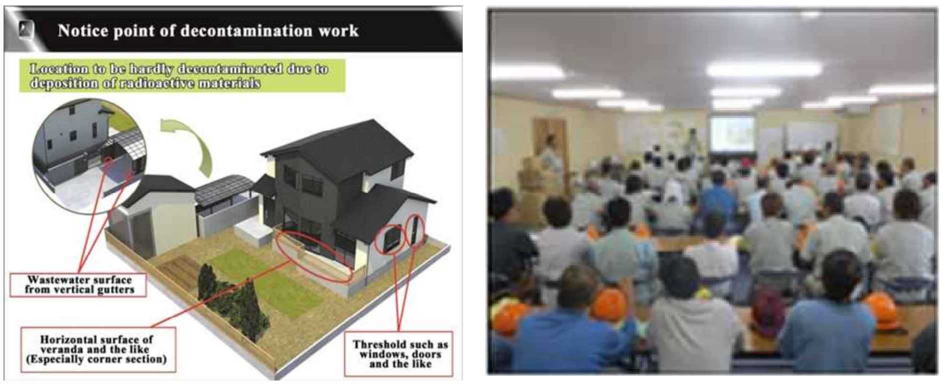


Figure 4-45 Example of an education session for decontamination workers by using video films or drawings[128].

Figure 4-46 Example scenes of safety activities[129].

[128]Source: Shimizu Corporation
[129]Source: Maeda Corporation

4.7.2. Morale and Conscientiousness of Workers

Decontamination work is more or less similar to cleaning work, being different from ordinary civil engineering or construction work to build structures. Decontamination workers cannot easily get the pleasure of achievement obtained by producing something or completing construction of something. It is a concern that decontamination workers may be demoralized in conducting huge numbers of boring tasks while paying attention to radiation protection. Such factors may cause deterioration in the quality of the decontamination work.

On the other hand, decontamination workers were encouraged by the responses of local residents to the outcome of decontamination work such as weeding, soil scraping or soil replacement. In such decontamination work, the apparent changes led to the people's positive responses: "Fields looked nicer after decontamination"; or "Fields helped me recover hope to return home, when weeds fully covering the fields were removed and the surfaces of rice fields and dry fields became visible after decontamination.

In the earlier stage of MOE decontamination works in the Special Decontamination Areas, the needs of the decontamination workforce were limited and a significant portion of decontamination workers were local residents under contract. They had high morale and were conscientious with clear aims to decontaminate their own land. It can be said that they brought about good tension in the work groups.

One decontamination business operator placed importance on sharing empathy with the local residents and developing teamwork spirit among decontamination workers. The operator took the following measures in order to upgrade the quality of decontamination work by clearly identifying the objective of the work as recovering environmental conditions for the residents to return home.

- Expressing strong hopes toward restoration by placing banners in public places.
- Reading slogans about the decontamination work out loud, with all workers responding, at daily morning assemblies.
- Encouraging mixing with other work group members at safety campaign events.
- Facilitating understanding of the construction workers (primary contractor's personnel, secondary contractors' personnel and other workers) toward restoration by having them live in the area to be decontaminated and arranging for them to mix with the local people.

Figure 4-47 Banners expressing hope and progress toward restoration of the area[130].

[130] Source: Taisei Corporation

Figure 4-48 Photos showing daily morning assemblies with reading of a slogan and response by all workers[131].

4.7.3. Personal Exposure Dose Management for Workers

For external exposure dose management, some decontamination business operators used, besides personal dosimeters, the access management system and other systems connected to the air dose measurement in the workplaces. Specifically, individual workers wore personal dosimeters, and read the indication before and after the day's work for measurement of the exposure dose for that day. The measured data were processed together with the information stored in the database and used for personal exposure dose management.

For internal exposure dose management, WBCs were used. Decontamination workers are required to receive periodical medical checks for ionizing radiation when engaged in decontamination and related works as well as the WBC measurement for internal exposure management. Decontamination workers are also required to receive such checks upon employment, upon transfer to different work locations and every six months. The measured data were processed together with the information stored in the data base and used for personal internal exposure dose management.

Figure 4-49 illustrates the results of personal cumulative exposure dose of decontamination workers in decontamination model projects in the Difficult-to-return Area (the area where it is expected that the residents have difficulties in returning for a long time). The decontamination model projects in the Difficult-to-return Area were conducted in Futaba Town and Namie Town where the air dose rate before decontamination had been as high as the level to cause about 50 to 100 mSv per year. Protective measures were taken such as not to have particular individuals work in high dose areas for a long time. Consequently, the maximum average personal exposure was 71.5 µSv/d over the work period of September 1, 2013 to February 22, 2014. This shows that, even if the person continues to work under similar conditions for 240 days (the average work days per year), the cumulative personal exposure dose would be 17.2 mSv, not exceeding the legally set annual dose limit of "100 mSv per five years AND 50 mSv per year."

[131]Source: Shimizu Corporation, Maeda Corporation

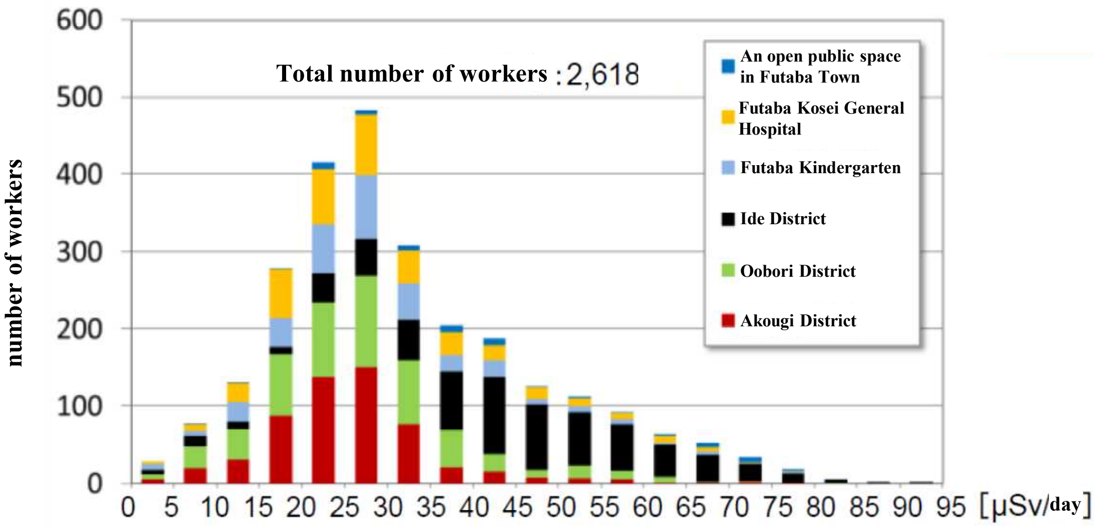


Figure 4-49 Example graph showing personal cumulative exposure dose of decontamination workers(From the decontamination model projects in the areas where it is expected that the residents have difficulties in returning for a long time)[132].

4.7.4. Medical Checks for Ionizing Radiation and Use of Whole Body Counters

The MOE opened two WBC Inspection Offices, one in Minami-soma City and the other in Naraha Town (having been moved to Tomioka Town) in order to make sure that workers of the decontamination business operators received WBC measurements before and after employment.

[132]Source: Ministry of the Environment (MOE), Results of decontamination model projects in areas where it is expected that the residents have difficulties in returning for a long time (June 10, 2014) (https://josen.env.go.jp/area/model2.html) (in Japanese)

5. Effects of Decontamination

5.1. Evaluation Pertaining to the Goals of the Basic Policy

The Basic Policy based on the Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District Off the Pacific Ocean Earthquake That Occurred on 11 March (hereafter refer to "Act on Special Measures") sets the goals for the measures for decontamination (Figure 5-1) and the Ministry of Environment (MOE) published the "Evaluation of the Goals of Basic Policy" in December 2013.

Basic Policy Based on the Act on Special Measures (excerpt)

(2) The following goals are set for the region with an additional exposure dose of less than 20 mSv/y.
a. The additional exposure dose of 1mSv/y or less shall be targeted as the long-term goal.
b. By the end of August 2013, the annual additional exposure dose of the general public shall be decreased by about 50% as compared with the value at the end of August 2011, by physical attenuation of radioactive materials and other effects also being taken into account.

c. It is important to restore the environment for children's life with peace of mind. Decontamination of children's living environments such as schools and parks shall be implemented with high priority, and by the end of August 2013, the annual additional exposure dose of children shall be decreased by about 60% as compared with the value at the end of August 2011, considering physical attenuation of radioactive materials and other effects.

Figure 5-1 Basic Policy based on the Act on Special Measures[133].

5.1.1. Facilities Subject to Evaluation

The evaluation was implemented covering about 33,000 facilities (about 12,000 facilities in Special Decontamination Areas; about 21,000 facilities in Intensive Contamination Survey Areas) and at about 330,000 measurement points (about 100,000 points in Special Decontamination Areas; about 230,000 points in Intensive Contamination Survey Areas), where the decontamination work had been carried out by the end of August 2013.

		School	Park, Square	Housing	Other facility	
Facility no.	Special Decontamination Area	24	123	4,645	153	
	Intensive Contamination Survey Area	2,229	1,980	12,513	456	
Measurement points no.	Special Decontamination Area	494	949	61,980	1,785	
	Intensive Contamination Survey Area	36,136	41,286	121,741	4,268	
		Road	Forest	Farmland	Pasture land	Total
Facility no.	Special Decontamination Area	1,792	2,319	3,204	111	12,371
	Intensive Contamination Survey Area	1,220	940	1,633	97	21,068
Measurement points no.	Special Decontamination Area	18,274	9,541	10,764	513	104,300
	Intensive Contamination Survey Area	8,496	2,678	10,404	2,919	227,928

＊ Special Decontamination Area･･･Tamura City, Kawamata Town, Kawauchi Village, Naraha Town, Okuma Town, Katsurao Village, Iitate Village (However, the measurement result of the data more than 3.8 μSv/h have been excluded)

Figure 5-2 Numbers of facilities and measurement points to be evaluated concerning the reduction of additional exposure dose[134].

[133] Source: Ministry of the Environment (MOE), Basic Policy Based on the Act on Special Measures Concerning the Handling of Radioactive Pollution, December 2011

[134] Source: Ministry of the Environment (MOE), "Evaluation concerning the goals of basic policy," December

5.1.2. Basic Approach of Evaluation Methods

The air dose rate at the end of August 2011 was estimated from the air dose rate measured before decontamination and the air dose rate at the end of August 2013 was estimated from the air dose rate measured after decontamination. The evaluation for each classification of facilities was done by integrating the air dose reduction rate by decontamination and the reduction rate by physical attenuation of radioactive materials and other effects.

It should be noted that the Basic Policy set its goal on the reduction of additional exposure dose. However, the additional exposure dose cannot be directly measured. The evaluation was done instead, on the assumption that the exposure dose was proportional to the air dose rate (Figure 5-3).

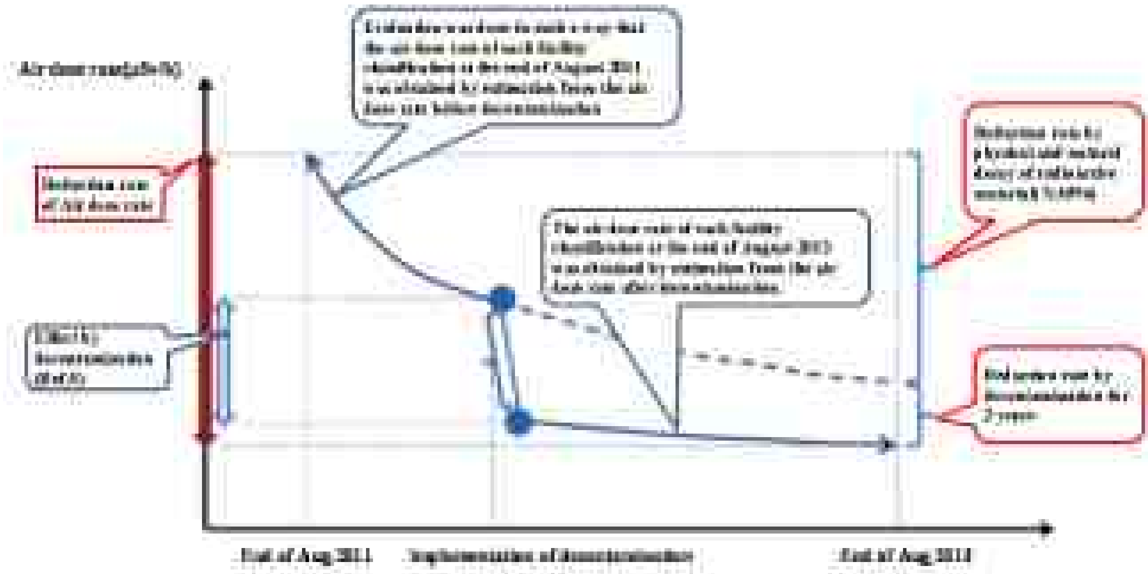


Figure 5-3 Basic concept of evaluation methods.

5.1.3. Evaluation Methods and Results

(1) Annual additional exposure dose of the general public

1) Evaluation methods

- The average additional radiation exposure dose was calculated for each facility classification* by estimating the air dose rate at the end of August 2011, using the measured values on a day before decontamination.
- The average additional radiation exposure dose was calculated for each facility classification* by estimating the air dose rate at the end of August 2013, using the measured values on a day after decontamination.
- The additional annual exposure dose was estimated as the total of the dose rate multiplied by a coefficient defined for each classified facility subject to life patterns.

* Concerning roads or forests, each unit divided by facility numbers in the investigation was dealt with as one facility. Evaluation of additional annual exposure dose of children was done in the same way.

2013 (Figure 5-3 to Figure 5-7 have the same source.)

2） Evaluation results

The goal of reducing the additional annual exposure dose was evaluated as having been achieved, as seen in the overall reduction rate of about 64% over the two year period (Figure 5-4).

	Additional exposure dose (%)	Contribution of physical attenuation effect (%)	Contribution of decontamination effect (%)
Goal	about 50	about 40	about 10
Special Decontamination Areas	about 67		about 27
Intensive Contamination Survey Areas	about 62		about 22
Overall	about 64		about 24

Figure 5-4 Evaluation results of reduction rate over 2 years (Annual exposure dose of the general public)

（2） Annual additional exposure dose of children

1） Evaluation methods

- The average additional radiation exposure dose was calculated for each facility classification* by estimating the air dose rate at the end of August 2011, using the measured values on a day before decontamination.
- The average additional radiation exposure dose was calculated for each facility classification* by estimating the air dose rate at the end of August 2013, using the measured values on a day after decontamination.
- The additional annual exposure dose was estimated as the total of the dose rate multiplied by a coefficient defined for each classified facility subject to life patterns.

2） Evaluation results

The goal of reducing the additional annual exposure dose was evaluated as having been achieved, as can be seen in the overall reduction rate of about 65% over the two year period (Figure 5-5).

	Reduction of additional exposure dose (%)	Contribution of physical attenuation effect (%)	Contribution of decontamination effect(%)
Goal	about 60	about 40	about 20
Special Decontamination Areas	about 66		about 26
Intensive Contamination Survey Areas	about 64		about 24
Overall	about 65		about 25

Figure 5-5 Evaluation results of reduction rate over 2 years (Annual additional exposure dose of children)

(3) Reduction rate of additional exposure dose for air dose rate range

Reduction rates of the additional exposure dose were evaluated for each air dose rate range before decontamination. Higher reduction rates of the additional exposure dose tend to be achieved in areas of higher air dose rate before decontamination. Higher reduction rates of children's additional exposure dose are higher than those of the general public for all air dose rate ranges.

Air dose rate (μSv/h)	Reduction of additional exposure dose (%)	Contribution of physical attenuation (%)	Contribution of decontamination effect (%)
0.99 or higher	about 73	about 40	about 33
0.80 to below 0.99	about 64		about 24
0.61 to below 0.80	about 63		about 23
0.42 to below 0.61	about 60		about 20
0.23 to below 0.42	about 55		about 15

Figure 5-6 Reduction rate of additional exposure dose for each air dose range (the general public).

Air dose rate (μSv/h)	Reduction of additional exposure dose (%)	Contribution of physical attenuation (%)	Contribution of decontamination effect (%)
0.99 or higher	about 74	about 40	about 34
0.80 to below 0.99	about 67		about 27
0.61 to below 0.80	about 67		about 27
0.42 to below 0.61	about 63		about 23
0.23 to below 0.42	about 58		about 18

Figure 5-7 Reduction rate of additional exposure dose for each air dose rate range (children).

5.2. Overview on the Decontamination Effects

The "Decontamination effects (air dose rate) in the decontamination work implemented by the National Government and local municipalities" (prepared by the MOE, Decontamination Team, December 2013) reviewed the decontamination effects (air dose rate) in the decontamination work to date, focusing on to what extent the air dose rate (at the height of 1 m) could be reduced by decontamination, from the viewpoint of evaluating the exposure dose to the general public.

5.2.1. Data for Evaluation

The report reviewed about 250,000 data (two measured values before and after decontamination per one measurement point) of the air dose rate (measured at the heights of 1 m and 50 cm; unit, µSv/h), roughly between March 2012 and October 2013 in the decontamination work implemented in JFY 2012 onward (in 10 municipalities under the National Government jurisdiction and in 90 municipalities in 8 prefectures under local jurisdiction).

The evaluation was limited to the data collected at the time of evaluation. Decontamination methods and decontamination target places include various types depending on the situations. In residential areas, for example, the evaluation of air dose rate was based on the results from various complex effects of gardens with soil, paved surfaces, roofs, walls, etc. The following data were excluded from the evaluation.

- The air dose rate data below 0.23µSv/h before decontamination.
- Top 1% and bottom 1% of the reduction rate data (Outlier data, unsuitable for grasping the overall trend).

Classification work	Land- use Classification	Air dose rate(1m)	Air dose rate(0.5m)
National Government	Public facilities *2	approx. 12,000	-
	Residential area	approx. 54,000	
	Road	approx. 28,000	-
	Farm land	approx. 11,000	-
	Forest	approx. 10,000	-
	Sum	approx.116,000	-
Local municipalities	Public facilities *2	approx. 36,000	-
	Residential area	approx. 37,000	-
	Road	approx. 6,000	-
	Farm land	approx. 10,000	-
	Forest	approx. 3,000	-
	Children's living environment *3	-	approx.40,000
	Sum	approx.92,000	approx.40,000
Total		approx.208,000	approx.40,000

Note: There is a case in which the total does not match due to rounding off the fractional.
＊1：Less than 0.23µSv/h of decontamination data before, data of upper reduction rate 1% and lower reduction rate 1% are excluded and calculated.
＊2：Public facilities include school, park or large facility.
＊3：Children's living environment include elementary school, kindergarten and park.

Figure 5-8 Data for evaluation[135].

5.2.2. Summary of the Results

- In terms of typical distribution ranges of air dose rate (the range here refers to rates between the 25th percentile value and the 75th percentile value), the air dose rate before decontamination was 0.36 to 0.93 µSv/h, and it was reduced to 0.25 to 0.57 µSv/h after

[135]Source: Ministry of the Environment (MOE), Decontamination Team, "Decontamination effects (air dose rate) implemented by the National Government and local municipalities," December 2013 (Figure 5-9 to Figure 5-14 have the same source.)

decontamination. As a whole, the air dose rate was reduced and at the same time, its distribution range became narrower after decontamination. This indicates the reduction rate of air dose rate by decontamination in the higher air dose rate areas is larger and the reduction rate in lower air dose rate areas is smaller.

- The air dose rate was reduced by decontamination by about 30 to 50% on average in all dose rate ranges (below 1μSv/h, 1 to 3.8μSv/h and above 3.8μSv/h, respectively, before decontamination). This indicates the higher the dose rates before decontamination, the larger the decontamination effects and the air dose rate reduction.
- In the current review, the evaluation was done by air dose rates (μSv/h) from the viewpoint of evaluating exposure dose of the general public. Regarding the difference of decontamination effects (reduction rates) depending on the target place and the decontamination methods, the evaluation results by surface contamination densities (cpm) were made public in January 2013, in which the decontamination effect by removing radiocesium from the decontamination targets had been confirmed.
- The air dose rate reduction features varied subject to influences from the surrounding area, depending on the characteristics of decontamination site, type of land-use and others.
- Concerning the relation between the type of land-use and decontamination effects, the decontamination effects were relatively high in the residential areas and relatively low in the forests. It should be noted that the data for forests do not directly indicate the effects on the neighboring living environment such as residential areas because the data for forests included a considerable number of data collected inside the forests.

  (Note) The forests were decontaminated by removing accumulated leaf litter and woody materials. The decontamination guidelines were revised based on the new knowledge obtained for more effective decontamination, by, for example, adding the removed accumulated organic materials to targets for the decontamination methods, and also by considering the migration of radiocesium over time.
- Regarding the living environment for children such as schools, parks, etc., there were some data measured at different heights. Therefore, the data were reviewed separately in individual cases. As the result, the reduction rate was roughly 50% to 80%, tending to be higher compared with that of the whole area (air dose rate at 1 m in height).

Air dose rate *1,2 (measurement hight 1m)	**Before decontamination : 0.36 to 0.93μSv/h** ⇩ **After decontamination : 0.25 to 0.57μSv/h**		
Reduction rate of air dose rate (average) *2,3	Before decontamination less than 1μSv/h	Before decontamination 1~3.8μSv/h	Before decontamination 3.8μSv/h or more
	32%	**43%**	**51%**
ex) Reduction rate of surface contamination density *4	Asphalt pavement of parking lot: washing is aprox.50 to 70% High-pressure washing is approx.30 to 70% Soil ground: stripping of surface soil is approx..80 to 90%		

＊1.Band of value of 25 percentile and 75 percentile of air dose rate.
＊2.Data at measurement height 0.5m is not included in the data of living environment for children on school etc..
＊3.Average data of reduction rate of air dose rate at each decontamination classification before.
(reduction rate(%) =(1-air dose rate before decontamination/ air dose rate before decontamination)×100)
＊4.Announcement "effect of decontamination method in the work by National Government and local municipalities" has been Press released on 18.Jan.2013.

Figure 5-9 Decontamination effects in the decontamination work implemented by the National Government and local municipalities (main results).

5.3. Decontamination Effects in Five Areas: Public Facilities, Residential Areas, Roads, Farmland and Forests

The “Decontamination effects (air dose rate) in the decontamination work implemented by the National Government and local municipalities” (prepared by the MOE, Decontamination Team, December 2013) reviewed the decontamination effects also by land-use classification (five categories consisting of: public facilities and the like; residential areas; roads; farmland; and forests) in addition to the review as a whole.

5.3.1. Public Facilities

- The data of public facilities and the like included various data such as those of ground surfaces of bare soil, asphalt paved surfaces, gravel, etc.
- About 70% of the data were from the facilities with the air dose rate below 1 µSv/h before decontamination and the average reduction rate for all public facilities was about 34%.
- In the areas with the air dose rate was below 1 µSv/h before decontamination, the average reduction rate was about 29% and the air dose rate after decontamination was 0.38µSv/h or less at half of the measurement points. The reduction rate was higher in the areas with higher air dose rate before decontamination and the average air dose rate at the points of 1 µSv/h before decontamination was about 0.6 µSv/h (a reduction rate of about 40%).
- In the areas with the air dose rate ranges of 1 to 3.8 µSv/h and 3.8 µSv/h or higher before decontamination, the reduction rates were higher in the areas with higher air dose rate as compared with those in the areas with the rate of less than 1 µSv/h, and the average reduction rate in the areas with the rate of more than 3.8 µSv/h before decontamination was about 53%.
- Most of the data with high air dose rate were data obtained by decontamination of a public facility as a single target. For this reason, the air dose rate of public facilities after decontamination tended to be higher when compared with the air dose rate of residences which were decontaminated zone-wise including the surroundings. However, the air dose rate of public facilities is expected to be reduced through decontamination of their surroundings.

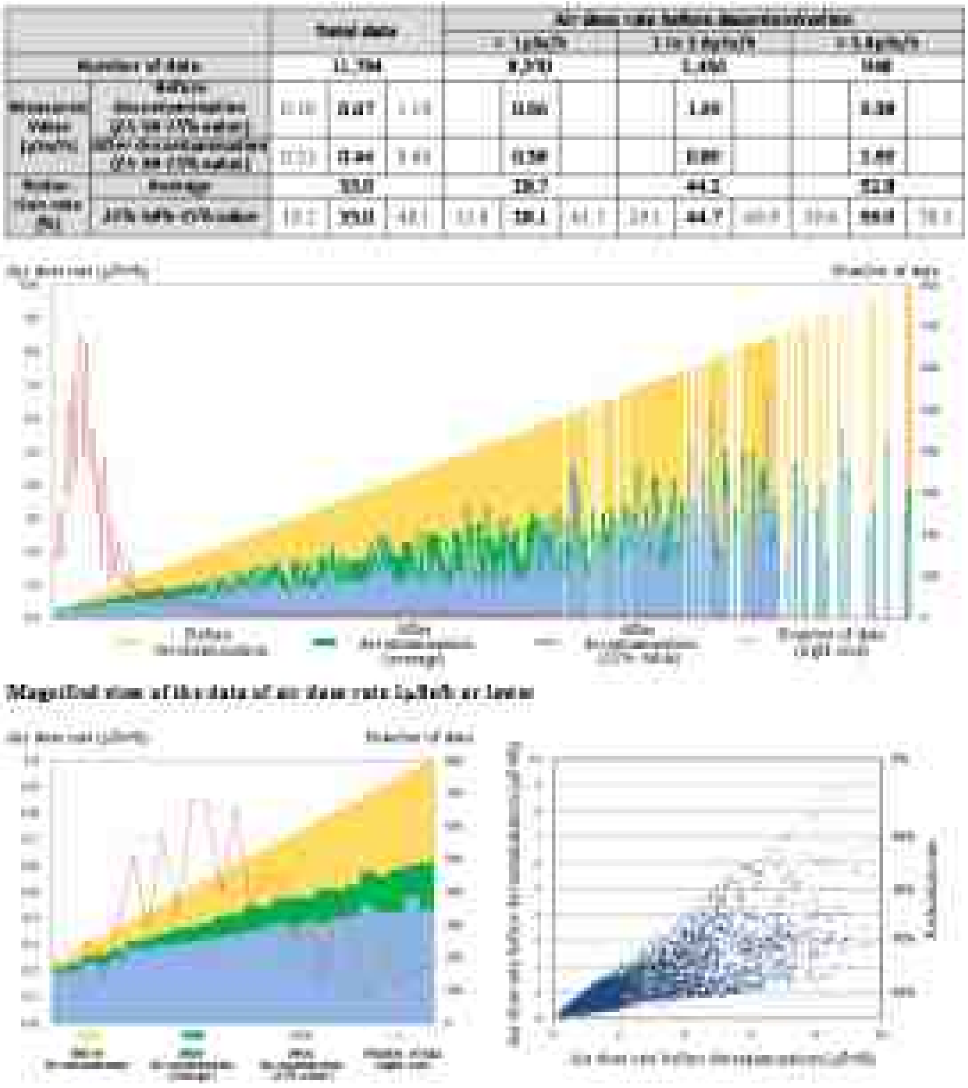


Figure 5-10 Air dose rate (at 1m) in the National Government work (public facilities).

5.3.2. Residential Areas

- The number of data measured in residential areas was about 50,000, about half of the data were from the work by the National Government, which included a wide variety of data such as bare soil, gardens, grass fields, gravel, concrete paved surfaces, etc.
- About 70% of the data were from the zones with the air dose rate below 1 µSv/h before decontamination and the average reduction rate for all residential areas was about 43%, which was relatively higher than for all decontamination work.
- In the zones with the air dose rate below 1 µSv/h before decontamination, the average reduction rate was about 40% and the air dose rate after decontamination was 0.33µSv/h or less at half of the measurement points. The reduction rate was higher in the zones with higher air dose rate before decontamination and the average air dose rate at the points of 1 µSv/h before decontamination was about 0.5 µSv/h after decontamination (a reduction rate of about 50%).
- In the zones with the air dose rate ranges of 1 to 3.8 µSv/h and 3.8 µSv/h or higher before decontamination, the reduction rates were higher in the areas with higher air dose rate as compared with those in the zones with the air dose rate of less than 1 µSv/h, and the average reduction rate in the zones with the air dose rate of more than 3.8 µSv/h before decontamination was about 57%.

		Total data			Air dose rate before decontamination								
					< 1μSv/h			1 to 3.8μSv/h			> 3.8μSv/h		
Number of data			52,866			37,198			15,479			187	
Measured Value [μSv/h]	Before decontamination [25/50/75% value]	0.51	0.75	1.10		0.60			1.51			4.36	
	After decontamination [25/50/75% value]	0.28	0.39	0.55		0.33			0.65			1.85	
Reduction rate [%]	Average		43.5			39.5			52.0			57.2	
	25%/50%/75% value	31.4	44.1	56.3	28.1	40.2	51.7	41.7	53.9	64.5	50.4	56.4	65.5

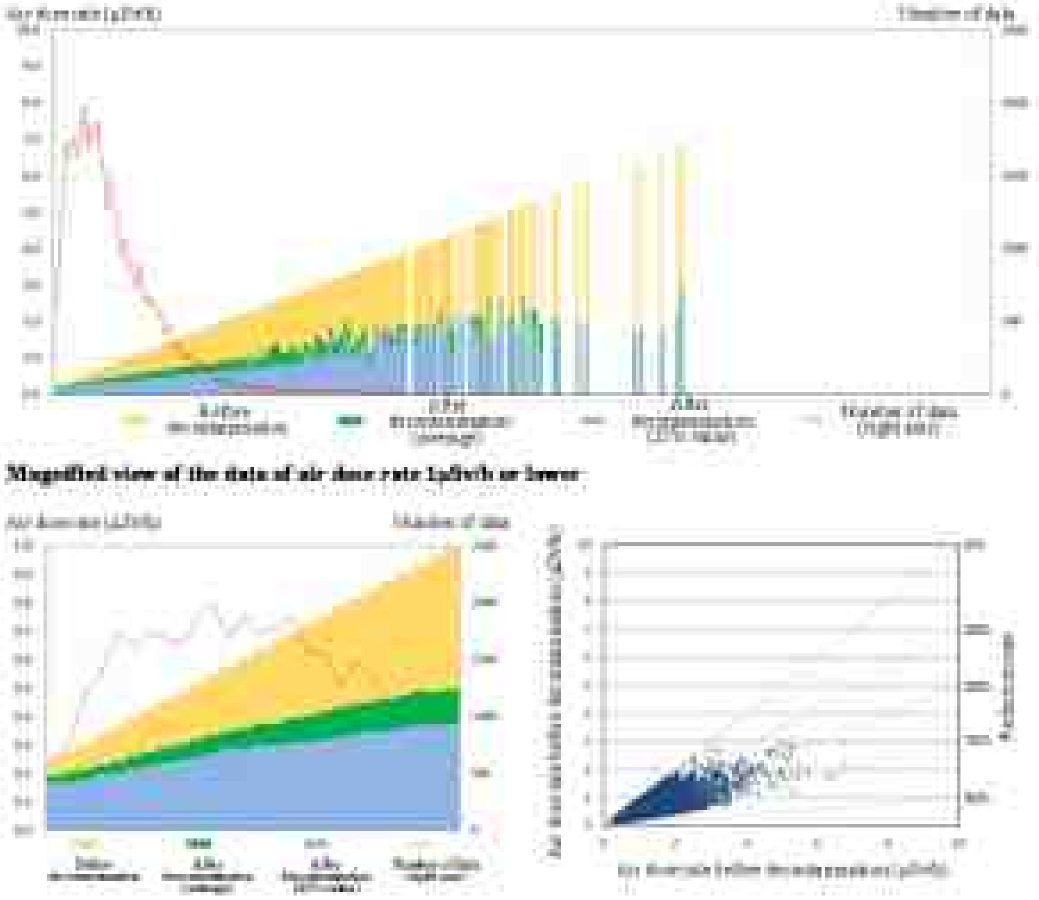
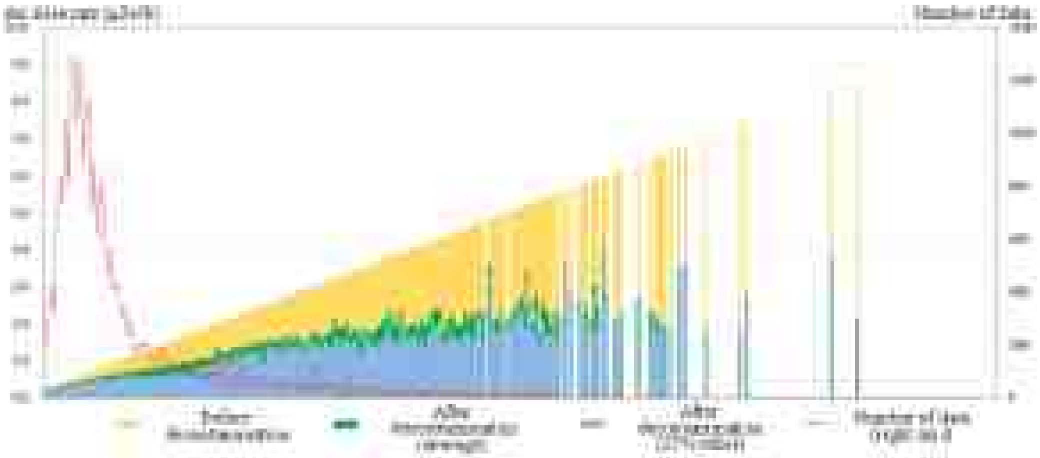


Figure 5-11 Air dose rate (at 1 m) in the National Government work (residential areas).

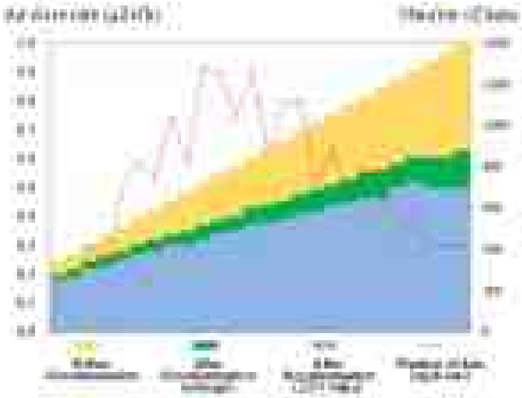
5.3.3. Roads

- The data for roads included those of paved roads, gravel and crushed stone roads, etc.
- About 70% of the data were from the roads with the air dose rate below 1 μSv/h before decontamination and the average reduction rate for all roads was about 33%.
- On the roads with the air dose rate below 1 μSv/h before decontamination, the average reduction rate was about 29% and the air dose rate after decontamination was 0.40μSv/h or less at half of the measurement points. The reduction rate was higher on the roads with higher air dose rate before decontamination and the average air dose rate at the points of 1 μSv/h before decontamination was about 0.6 μSv/h after decontamination (a reduction rate of about 40%).
- On roads with the air dose rate ranges of 1 to 3.8 μSv/h and 3.8 μSv/h or higher before decontamination, the reduction rates were higher on roads with higher air dose rate as compared with that on the roads with the air dose rate of less than 1 μSv/h, and the average reduction rate on the roads with the air dose rate of more than 3.8 μSv/h before decontamination was about 53%.

		Total data			Air dose rate before decontamination								
					< 1μSv/h			1 to 3.8μSv/h			> 3.8μSv/h		
Number of data		27,8[illegible]			19,2[illegible]			7,9[illegible]			6[illegible]		
Measured value (μSv/h)	Before decontamination (25-50-75% value)	[illegible]	0.75	[illegible]		0.60			1.60			4.30	
	After decontamination (25-50-75% value)	[illegible]	0.49	[illegible]		0.40			0.91			2.10	
Reduction rate (%)	Average		35.1			28.8			41.8			53.8	
	25%-50%-75% value	[illegible]	33.3	[illegible]	[illegible]	28.6	[illegible]	[illegible]	41.4	[illegible]	[illegible]	54.2	[illegible]



Magnified view of the data of air dose rate 1μSv/h or lower



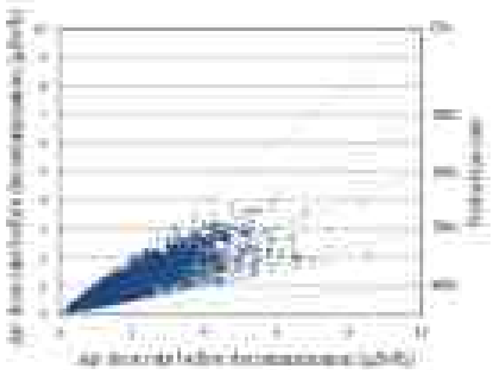


Figure 5-12 Air dose rate (at 1m) in the National Government work (roads).

5.3.4. Farmland

- The data on farmland included those on orchards and pasture land, but most of them were data on plowed land (deep plowing, top soil scraping). Most of the data on farmland with the air dose rates exceeding about 2μSv/h before decontamination were obtained from the farmland where decontamination was done by topsoil scraping.
- About 70% of the data were from farmland with the air dose rate below 1 μSv/h before decontamination and the average reduction rate for all farmland was about 34%.
- On farmland with the air dose rate below 1μSv/h before decontamination, the average reduction rate was about 28% and the air dose rate after decontamination was 0.44μSv/h or less at half of the measurement points. The reduction rate was higher on the farmland with the higher air dose rate before decontamination and the average air dose rate at the points of 1 μSv/h before decontamination was about 0.6 μSv/h (a reduction rate about 40%).
- On farmland with the air dose rate ranges of 1 to 3.8 μSv/h and 3.8 μSv/h or higher before decontamination, the reduction rates were higher on farmland with higher air

dose rate as compared with those on farmland with the air dose rate of less than 1 µSv/h. On farmland with the air dose rate exceeding about 2 µSv/h before decontamination, the air dose rate was reduced to about 1 µSv/h, regardless of the air dose rate before decontamination, because the decontamination was mostly by topsoil scraping.

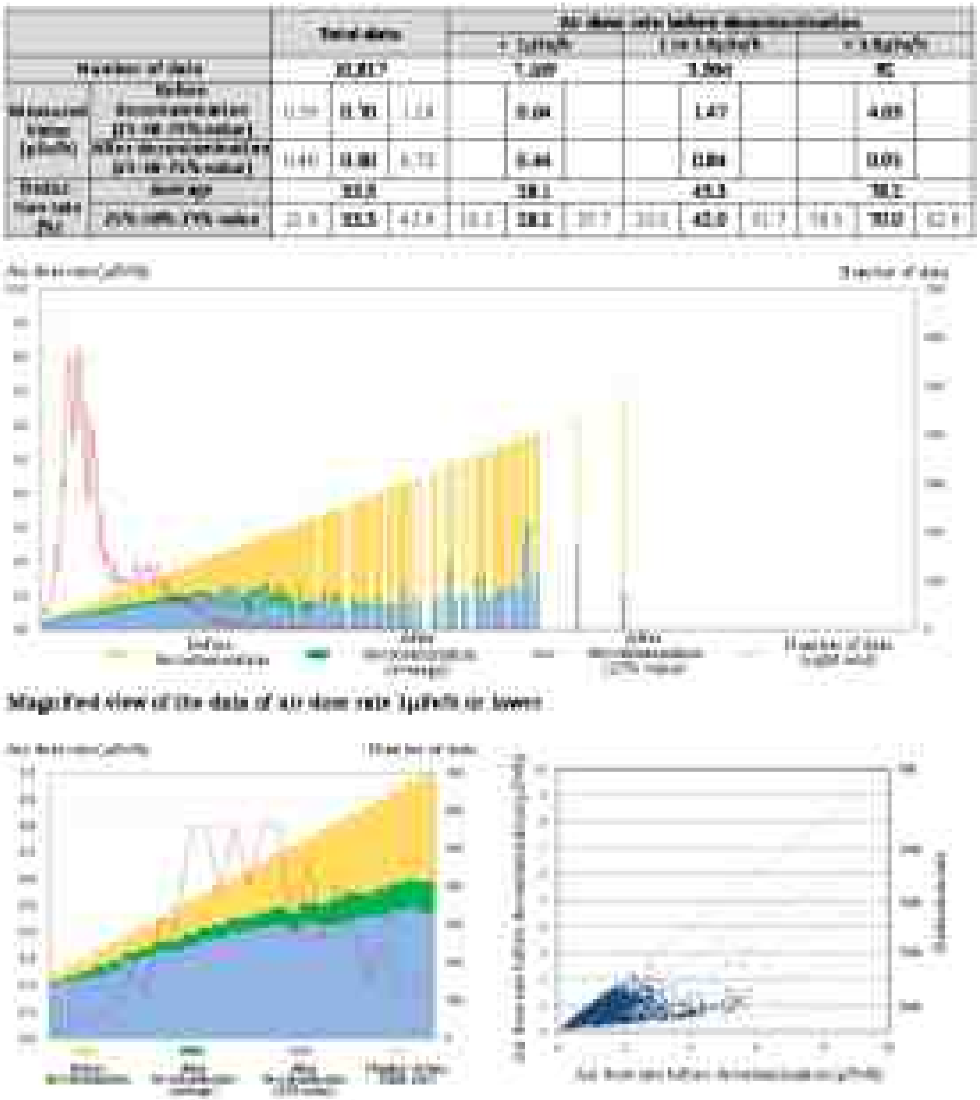


Figure 5-13 Air dose rate (at 1m) in the National Government work (farmland).

5.3.5. Forests

- Most data of forests were those obtained by removing organic matter such as fallen leaves and woody materials.
- About 60% of the data were from forests with the air dose rate of below 1 µSv/h before decontamination, lower in proportion of the data than in other land-use categories. The average reduction rate for all forests was about 22%, lower than for all decontamination work.
- For forests with the air dose rate below 1 µSv/h before decontamination, the average reduction rate was about 18% and the air dose rate after decontamination was 0.57µSv/h or less at half of the measurement points. The reduction rate was higher for forests with the higher air dose rate before decontamination and the average air dose

rate at the points of 1 μSv/h before decontamination was about 0.75 μSv/h (a reduction rate of about 25%).

- For forests with the air dose rate of 1 μSv/h or higher before decontamination, the reduction rate was slightly higher than that for the forests with the air dose rate of less than 1 μSv/h before decontamination, and the average reduction rate for the forests with the air dose rate of 1 to 3.8 μSv/h before decontamination was about 27%.
- It should be noted that the data for forests do not directly indicate the effects on the neighboring living environments such as residential areas because the data for forests included a considerable number of data collected inside the forests.

		Total data			Air dose rate before decontamination								
					< 1μSv/h			1 to 3.8μSv/h			> 3.8μSv/h		
Number of data			10,111			[illegible]			[illegible]			176	
Measured Value (μSv/h)	Before decontamination (25%/50%/75% value)	0.67	0.88	1.23		0.78			1.38			4.55	
	After decontamination (25%/50%/75% value)	0.54	0.70	0.85		0.57			1.08			3.53	
Reduction rate (%)	Average		21.9			17.8			27.4			38.6	
	25%/50%/75% value	11.1	20.4	31.4	8.3	16.4	25.7	17.0	24.8	37.4	[illegible]	26.5	[illegible]

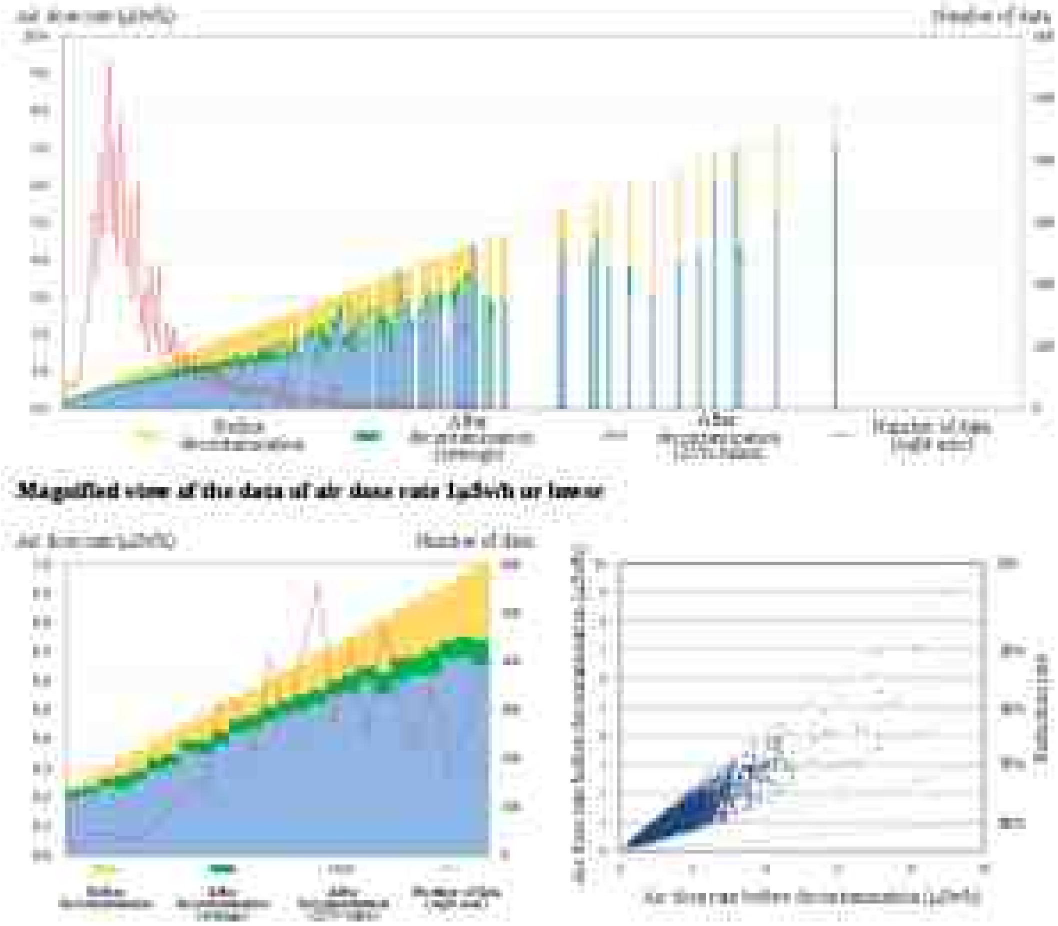


Figure 5-14 Air dose rate (at 1m) in the National Government work (forest).

5.4. Effects at Each Target Decontamination Place

The “Effectiveness of decontamination methods in the decontamination work implemented to date by the National Government and local municipalities” (prepared by the MOE, Decontamination Team, January 2013) reviewed the results of decontamination work in the early stage (mainly in JFY 2011) implemented by the National Government and local municipalities mostly in the area with comparatively high dose areas in Fukushima Prefecture, focusing on to what extent the radioactive materials could have been reduced by decontamination work.

5.4.1. Outline

- The data collected mainly in the neighboring areas of residential areas such as buildings and structures, roads, etc. were reviewed, which had been obtained in the decontamination work at the first stage. (Data one plowed land and forests were excluded from the review because the numbers of data points were insufficient.)
- The effectiveness of decontamination methods was evaluated in terms of reduction rates of surface contamination densities because the review purpose was to evaluate the effectiveness of each decontamination method.
- The data to be reviewed were limited to those with surface contamination densities before decontamination of higher than 2,000 cpm, in order to reduce data deviations due to the influences from objects other than the target object.

Object	Number of Data (2,000cpm or more)	Number of Data (whole data)	Decontamination method for analysis
Rainwater gutter	343	772	High-pressure washing, Swabbing after removal of sediments
Rainwater basin	85	214	High-pressure washing after removal of sediments
Side ditch	132	306	Removal of sediments, High-pressure washing after removal of sediments
Roof	464	751	Wiping, Washing, High-pressure washing
Outer wall	64	997	Wiping, Washing, High-pressure washing
Garden ground	446	628	Grass mowing, Stripping of top soil, Soil replacement, Peeling off of lawn
Pavement surface of parking lots	601	781	Washing, High-pressure washing, Scraping off
Ground (soil)	271	343	Stripping of top soil
Road (surface of asphalt pavement)	506	539	Washing, Pressure washing, Scraping off
Total	2,912	5,331	

Figure 5-15 Target objects of decontamination, numbers of data and decontamination methods[136].

[136]Source: Ministry of the Environment (MOE), Decontamination Team, "Effectiveness of decontamination methods in the decontamination work implemented to date by the national government and local municipalities", January 2013 (Figure 5-16 to Figure 5-29 have the same source.)

5.4.2. Effectiveness of Decontamination Methods for Each Target Decontamination Place

（1） Buildings and structures

1）Rainwater gutters and street drains

a.) Rainwater gutters

- The reduction rate of surface contamination densities was around 60 to 80% by wiping after sediment removal and around 40 to 80% by high-pressure water washing after sediment removal. Higher reduction rate by wiping after sediment removal was achieved than by high-pressure water cleaning.
- Substantial amounts of radioactive materials were accumulated in the sediments in rainwater gutters. It should be noted that sediment removal is an effective approach for decontamination.

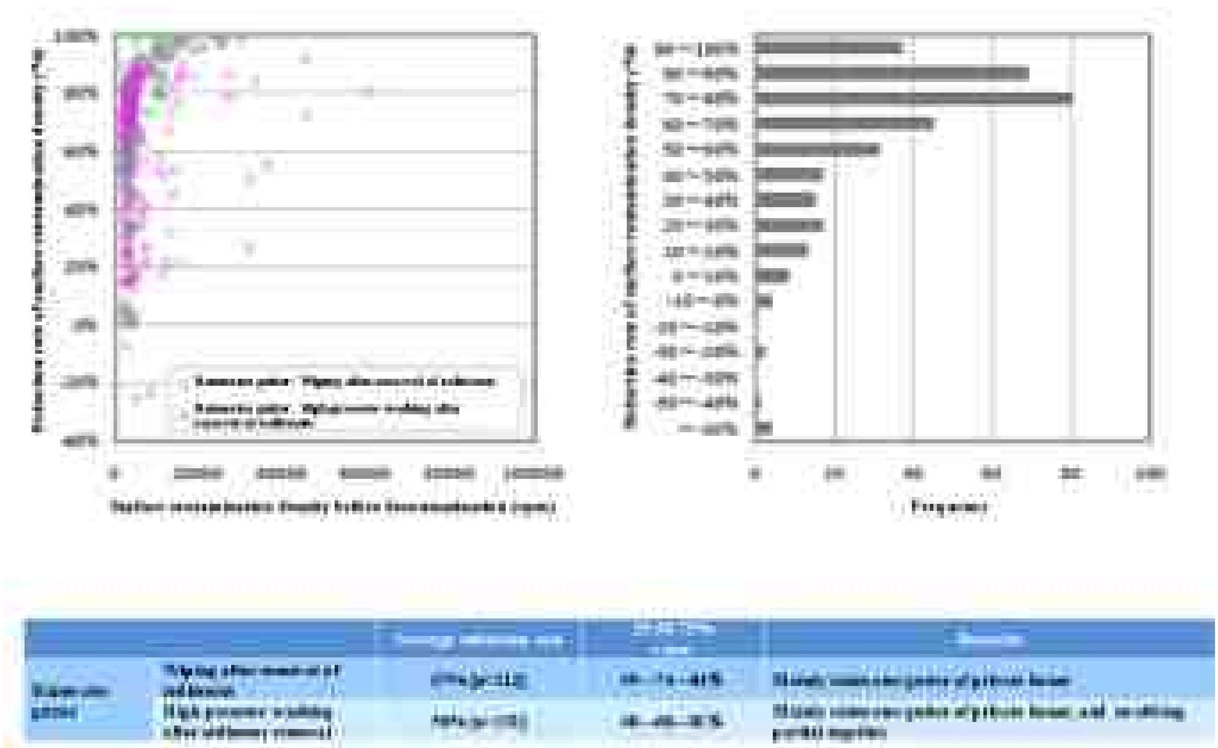
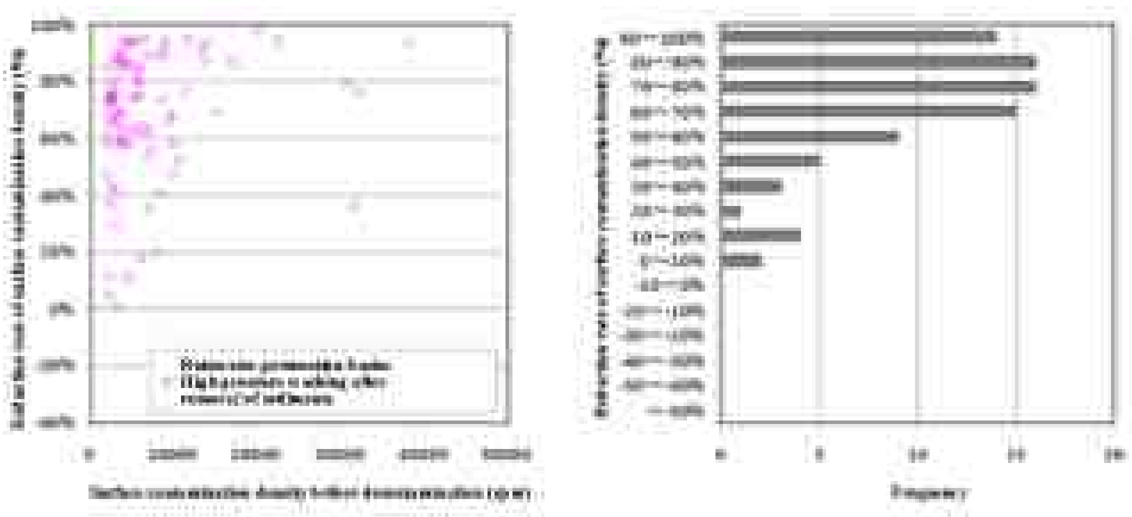


Figure 5-16 Decontamination effect for a target decontamination place (rainwater gutters).

b.) Rainwater cisterns

- The reduction rate of surface contamination densities was around 60 to 90% by high-pressure water washing after sediment removal.
- The effect by sediment removal was considered large, too.
- It should be noted in data interpretation that radioactive materials sunk into seams or cracks in high concentrations from rainfall in the early stage after the nuclear power plant accident and lowered the reduction rate.
- It is a point of careful attention in decontamination that soil and other objects in the surrounding area might be contaminated in case the rainwater cisterns are damaged and leaking.

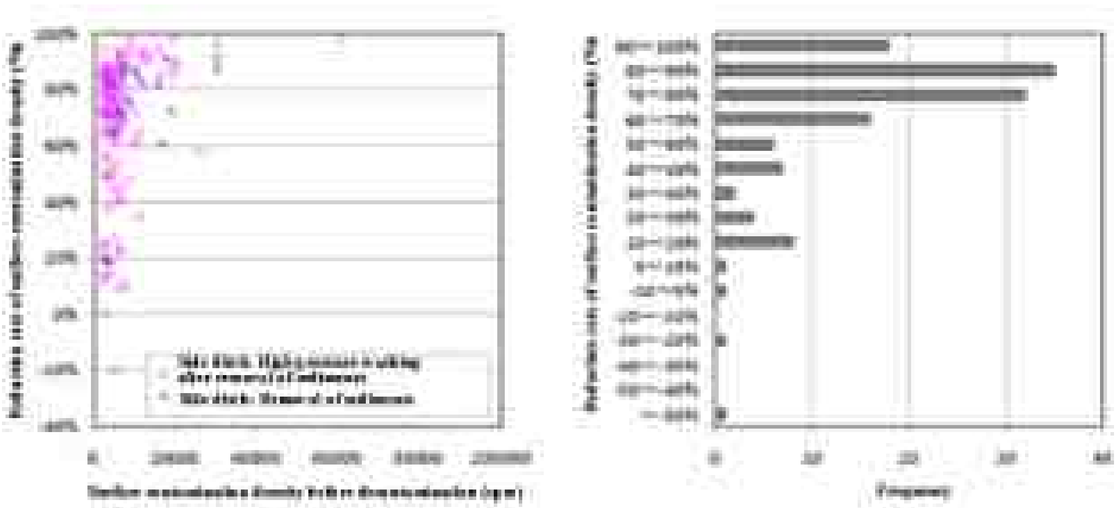


[illegible]	[illegible]	[illegible]	[illegible]	Remarks
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 5-17 Decontamination effect for a target decontamination place (rainwater cisterns).

c.) Street drains

- The reduction rate of surface contamination densities was around 70 to 90% by sediment removal and around 60 to 90% by high-pressure water washing after sediment removal.
- Substantial amounts of radioactive materials were accumulated in street drains. It is a point of careful attention in decontamination that simple removal of sediments can be effective enough and that the possibility should be considered for contamination of the soil and other objects in the surrounding area in case the street drains are damaged and leaking.



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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

Figure 5-18 Decontamination effect for a target decontamination place (street drains).

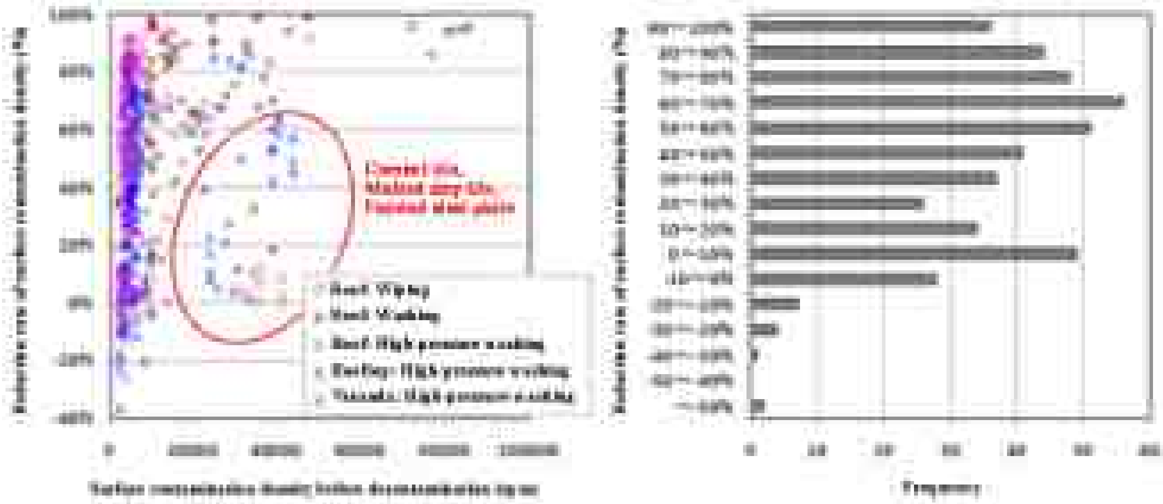
2）Roofs and other house structures

- The reduction rate of surface contamination density on the roofs was around 0 to 20% (*) by wiping, around 20 to 60% by water washing, and 40 to 80% by high-pressure water washing. (* The reduction rate was improved to 20 to 50% using a better way of wiping in the decontamination of roofs of private houses implemented in the autumn of 2012.)
- The reduction rate for rooftops was around 60 to 90% by high-pressure water washing. The rooftop shapes are generally not very complicated and therefore the high-pressure water washing is effective.
- The reduction rate for verandas and similar structures was around 20 to 50% by high-pressure water washing. But the available data were limited. If the high-pressure water washing was done after the sediments were removed, the reduction rate reached around 60 to 90%.
- Points of attention in data interpretation are:

  - ✓ Data for roofs had deviations depending on their shapes or surface materials.
  - ✓ Data deviations occurred in high-pressure water washing, since contaminated wastewater was left.
  - ✓ Low reduction rates were experienced in some cases of water washing and wiping of roofs even with high surface contamination densities before decontamination. These cases were for cement tiles, unglazed clay tiles and painted steel plates. The cause of the low reduction rate is considered to have come from the influence of rust or the roof materials themselves.

- Points of attention in decontamination are:

  - ✓ Measures should be taken to prevent wastewater from spreading when decontaminating using water.
  - ✓ If rust is present, it should be removed by wiping and other means before high-pressure water washing, because its presence lowers the effect.
  - ✓ A possibility should be considered in high-pressure water washing of damaging the structures, for instance, peeling off their surface materials.



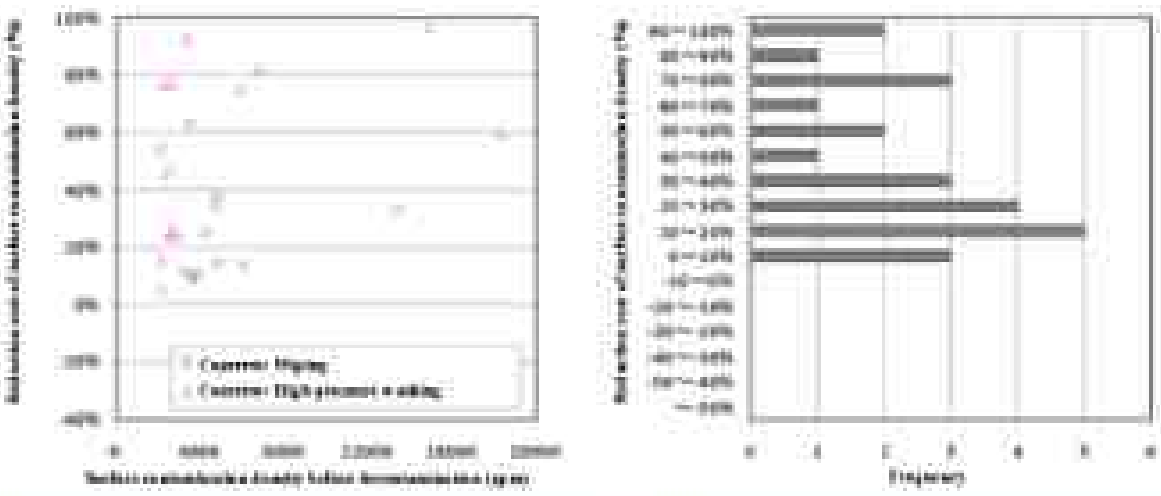
		[illegible]	[illegible]	[illegible]
Roof	Wiping	[illegible]	[illegible]	[illegible]
	Washing	[illegible]	[illegible]	[illegible]
	High pressure washing	[illegible]	[illegible]	[illegible]
Roofing	High pressure washing	[illegible]	[illegible]	[illegible]
Veranda	High pressure washing	[illegible]	[illegible]	[illegible]

Figure 5-19 Decontamination effect for a target decontamination place (roofs and others).

3）Exterior walls

a.) Concrete walls

- The reduction rates of surface contamination densities were around 10 to 30% by wiping and around 20 to 80% by high-pressure water washing. However, the data of wiping were limited.
- Many data were available for low surface contamination densities (less than 2,000 cpm) before decontamination. This is likely because the amount of radioactive materials attached was small or the radioactive materials had been washed away to some extent by rainfall.
- It is a point of attention in data interpretation that contamination of exterior walls was generally low, since rain, dust and other things were less likely to be attached on the walls than on the roofs, rainwater gutters, etc.
- Points of attention in decontamination are:
  - ✓ The need for decontamination should be assessed by comparing the background radiation levels and the contaminated situation of the objects.
  - ✓ A possibility should be considered in high-pressure water washing of damaging the structures, for instance, peeling off wall surface materials.



		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

Figure 5-20 Decontamination effect for a target decontamination place (concrete).

b.) Metal walls, windows, doors and shutters, etc.

- Few data were available for metal walls, windows, doors and shutters, etc.
- For metal walls, the reduction rate was around 40 to 70% by cleaning and around 40 to 90% by high-pressure water washing.
- For windows, doors and shutters, the reduction rate was around 70 to 80% by wiping, around 20 to 70% by water washing, and around 50 to 90% by high-pressure water washing.
- Many data were available for low surface contamination densities (less than 2,000 cpm) before decontamination. This is likely because the amount of radioactive materials attached was small or radioactive materials had been washed away by rainfall.
- It is a point of attention in data interpretation that the contamination of windows, doors and shutters is generally low, since rain, dust and other things are less likely to be attached on these surfaces than on the roofs, rainwater gutters, etc.
- It is a point of attention for decontamination that the need should be assessed by comparing the background radiation levels and the contaminated situation of the objects.

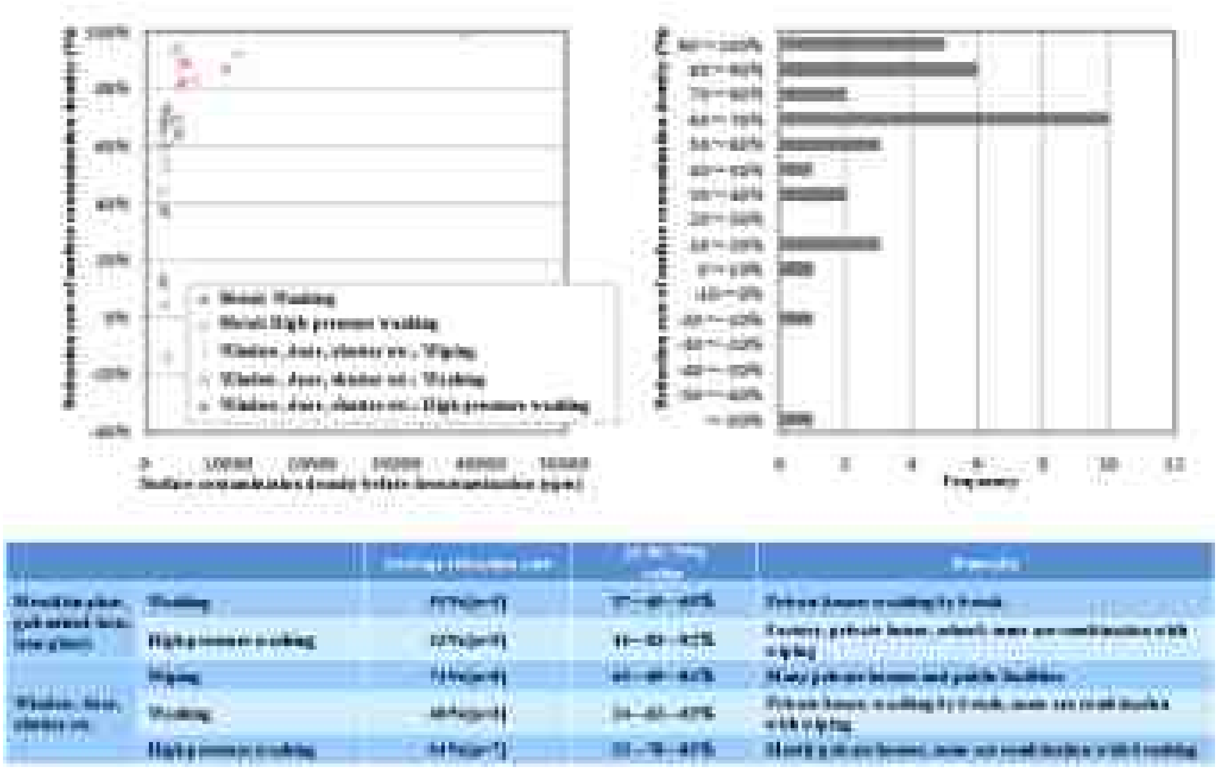
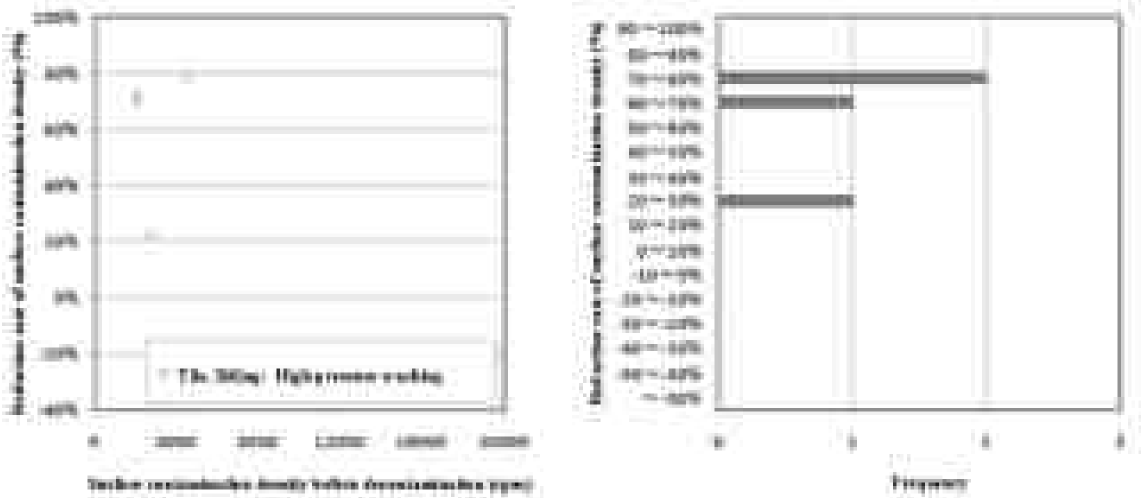


Figure 5-21 Decontamination effect for a target decontamination place (metal walls, windows, doors and shutters, etc.).

c.) Tiles and sidings

- The reduction rate of surface contamination densities was around 60 to 70% by high-pressure water washing. But the data were limited.
- The reduction rate by high-pressure water washing of tiles and sidings was higher than that of concrete walls.
- Many data were available for low surface contamination densities (less than 2,000 cpm) before decontamination. This is likely because the amount of radioactive materials attached was small or the radioactive materials had been washed away by rainfall.
- It is a point of attention in data interpretation that the contamination of tiles and sidings is generally low, since rain, dust and other things are less likely to be attached on the tiles and sidings than on the roofs, rainwater gutters, etc.
- It is a point of attention for decontamination that the need should be assessed by comparing the background radiation levels and the contaminated situation of the objects.



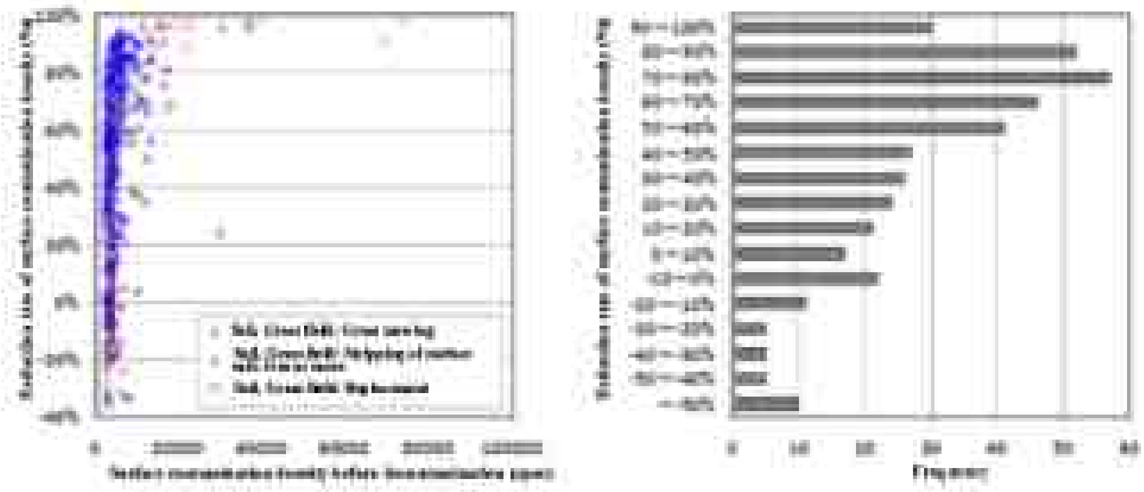
		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 5-22 Decontamination effect for a target decontamination place (tiles and sidings).

4) Ground surfaces such as gardens

a.) Bare soil and grassland

- The reduction rate of surface contamination densities was around 0 to 60% by grass mowing, around 40 to 80% by topsoil scraping, and around 70 to 100% by soil replacement.
- Soil replacement was applied in cases where the surface contamination density was relatively high before decontamination.
- The points of attention in data interpretation are:
  - ✓ Topsoil scraping of gardens may lower the certainties of decontamination work because of the presence of vegetation or more unevenness than on other types of ground surfaces.
  - ✓ The effect of decontamination by grass mowing may possibly change because the attachment of radioactive materials to the grass changes with time and also as grass grows uptake of radioactive materials may occur.
  - ✓ In some cases, the reduction rate becomes lower due to decrease of shielding effects of beta rays by grass as a result of mowing.



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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

Figure 5-23 Decontamination effect for a target decontamination place (bare soil, grassland)

b.) Lawns

- The reduction rate of surface contamination densities was high; 70 to 90% by peeling off of lawns and about 90% by soil replacement (coverage with crushed stones after removal of lawns).
- It is a point of attention in decontamination that it is necessary to consider “close mowing combined with topsoil removal(*),” for which a certain effect of dose reduction has been confirmed, from the viewpoint of controlling the amount of removed soil generated as well as regeneration of the lawns.
  (*) Close mowing combined with topsoil removal: a method to remove the topsoil including the root layer of dead lawns and other grasses depending on the situation of radioactive materials.

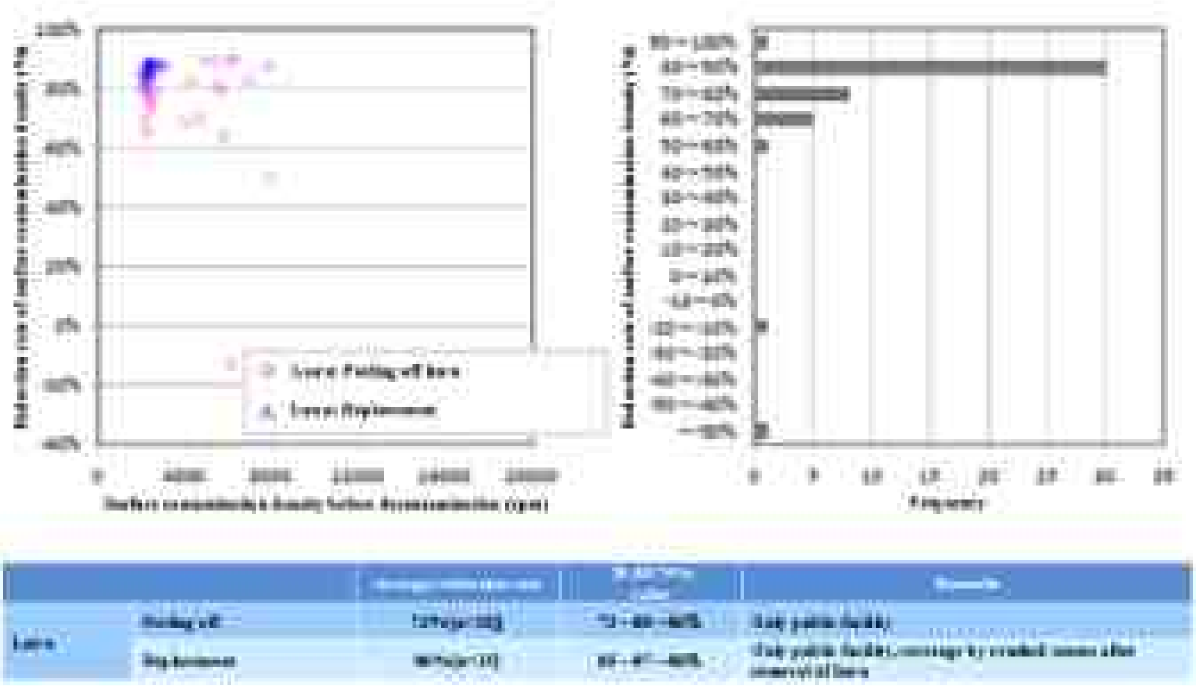
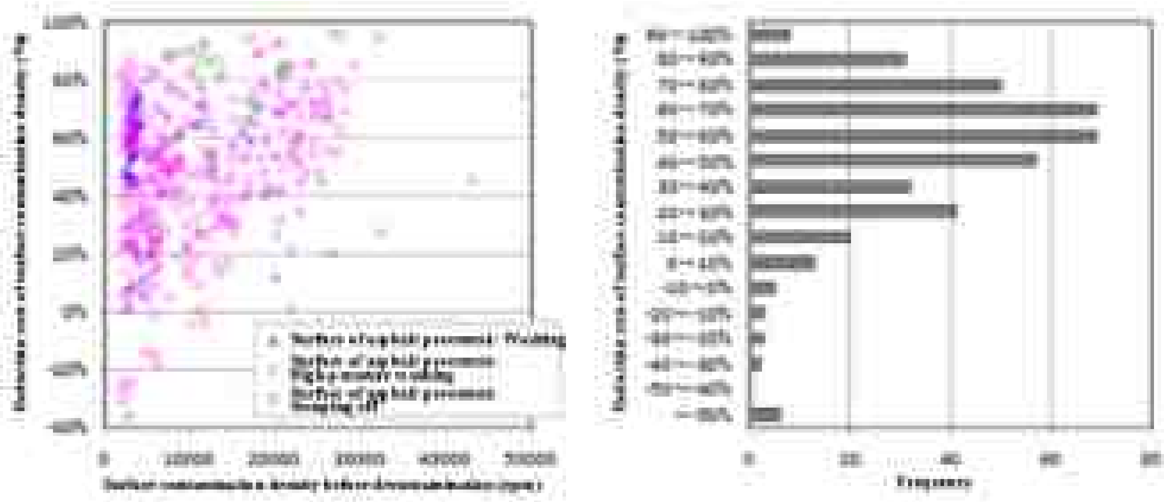


Figure 5-24 Decontamination effect for a target decontamination place (lawns).

5) Paved surfaces such as parking lots

a.) Asphalt paved surfaces

- The reduction rate of surface contamination densities was around 50 to 70% by cleaning, around 30 to 70% by high-pressure water washing, and around 70 to 90% by surface scraping.
- In high-pressure water washing, the reduction rate had large deviations irrespective of surface contamination densities before decontamination.
- A point of attention in data interpretation is that the decontamination effects may have large deviations because of variations in decontamination conditions of high-pressure water washing at each decontamination place (nozzle elevations above ground surface, work time per unit area, and other conditions) and the size of the area to be decontaminated like parking lots or the different conditions of paved surfaces (permeability or drainage capability).
- Points of attention in decontamination are:
  - ✓ Measures should be taken to prevent wastewater from spreading when decontaminating using water.
  - ✓ The possibility that radioactive materials may have deposited into cracks should be considered.



		[illegible]	[illegible]	[illegible]
Surface of asphalt pavement	Washing	[illegible]	[illegible]	[illegible]
	High-pressure washing	[illegible]	[illegible]	[illegible]
	Scraping off	[illegible]	[illegible]	[illegible]

Figure 5-25 Decontamination effect for a target decontamination place (asphalt paved surfaces).

b.) Concrete paved surfaces

- The reduction rate of surface contamination densities was around 40 to 70% by high-pressure water washing and around 60 to 90% by surface scraping.
- The reduction rate varies depending on the work method of surface scraping.
- A point of attention in data interpretation is that the decontamination effects may have large deviations because of variations in decontamination conditions of high-pressure water washing at each decontamination place (nozzle elevations above ground surface, work time per unit area, and other conditions) and the size of the area to be decontaminated like parking lots or the different conditions of paved surfaces (permeability or drainage capability).
- Points of attention in decontamination are:

  ✓ Relatively high reduction rates are obtained on the concrete surfaces because of less unevenness, but contamination tends to be concentrated around moss-covered spots.

  ✓ Measures should be taken to prevent wastewater from spreading when decontaminating using water.

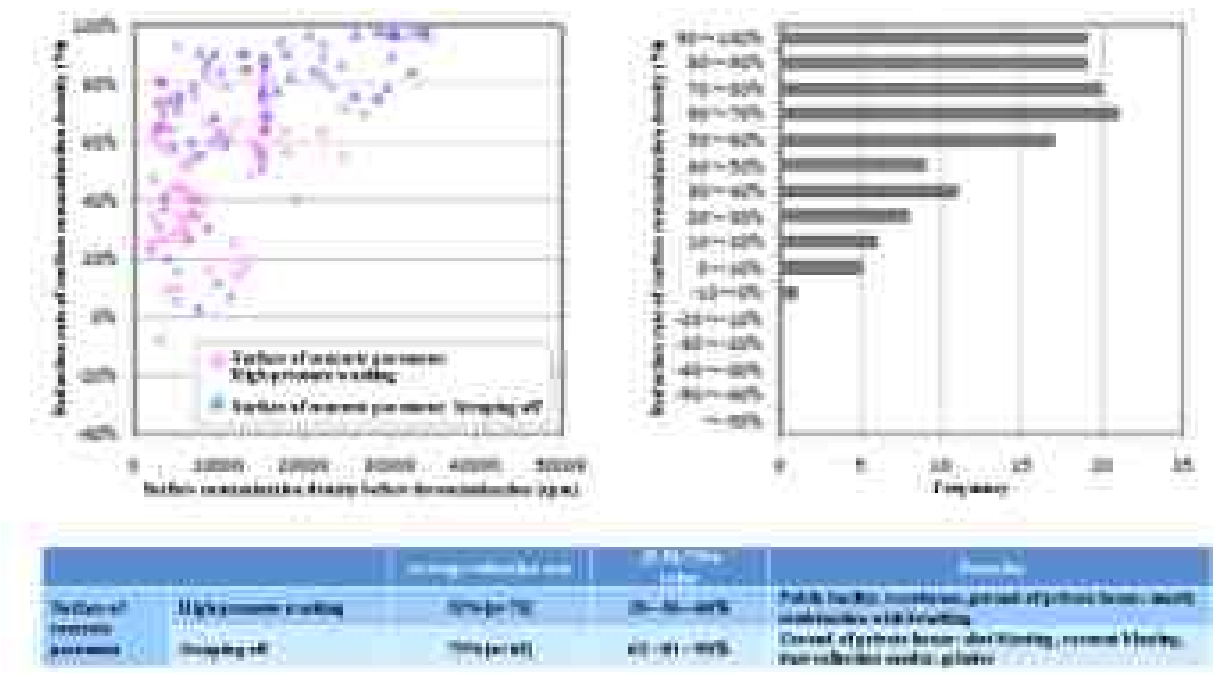


Figure 5-26 Decontamination effect for a target decontamination place (concrete paved surfaces).

c.) Interlocking block surfaces

- The reduction rate of surface contamination densities was around 50 to 80% by high-pressure water washing and around 40 to 70% by scraping.
- Points of attention in data interpretation are:
  - ✓ The reduction rate can be lowered in scraping if scraped chips and radioactive materials are left in the gaps between the interlocking blocks.
  - ✓ The reduction rate by scraping (abrasive material blasting and concrete surface planing) of interlocking blocks is lower than that by scraping of asphalt paved or concrete paved surfaces. The scraped chips left in the gaps of interlocking are likely one reason for this.

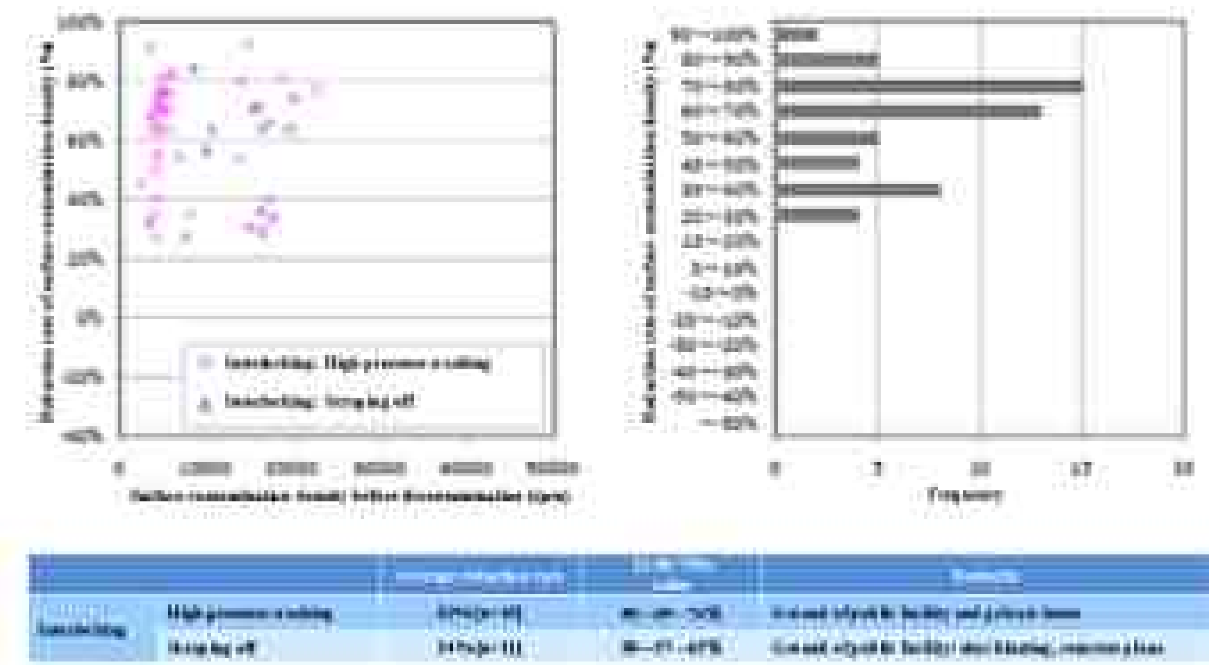


Figure 5-27 Decontamination effect for a target decontamination place (interlocking blocks).

6）Ground surfaces and the like (soil)

- High reduction rates of around 80 to 90% were achieved by topsoil scraping.
- Stable reduction rates seem to have been obtained, since the grounds have limited unevenness.
- It is a point of attention in decontamination that it is necessary to check the depth of contamination from the surface layer in advance and determine the optimum thickness of scraping.

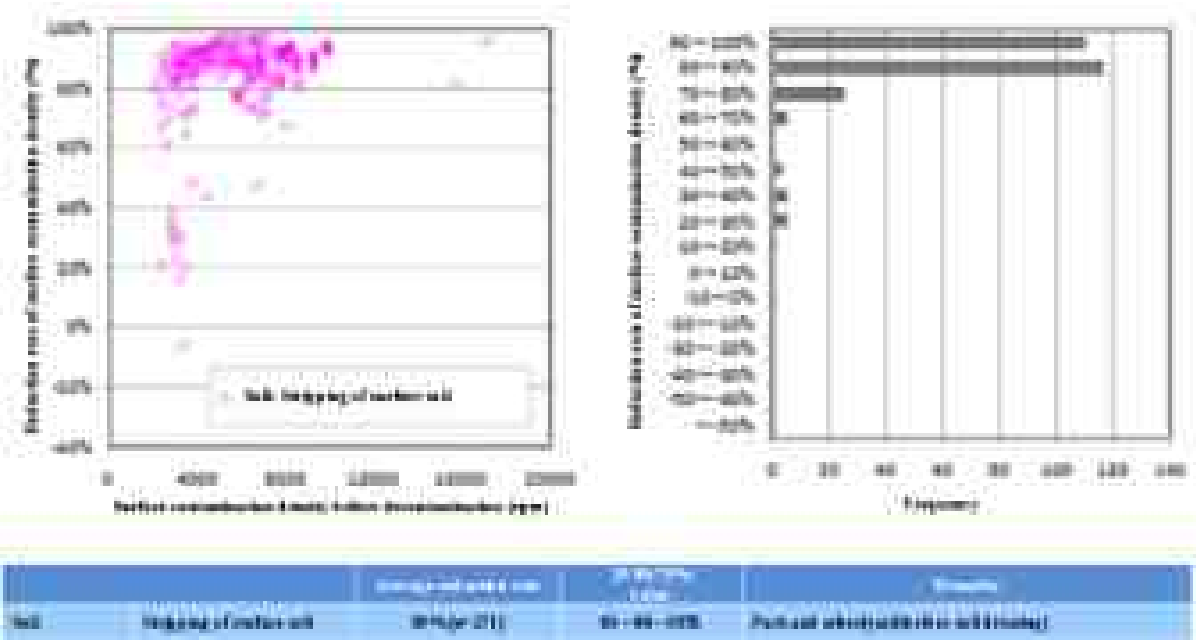


Figure 5-28 Decontamination effect for a target decontamination place (ground surfaces and the like (soil)).

(2) Roads (asphalt paved surfaces)

- Most data are from decontamination by cleaning and the reduction rate was around 0 to 50%. Large deviations were seen in the reduction rate because most data were obtained from decontamination by special cleaning vehicles that restore permeable pavement.
- The reduction rate by high-pressure water washing was around 10 to 50%. However, the data were limited.
- The reduction rate by scraping was around 10 to 70% (* the reduction rate is currently being improved by better collection of scraped chips.)
- The reduction rates of the asphalt-paved roads by any decontamination methods of cleaning, high-pressure water washing, or scraping were in many cases lower than those of asphalt-paved surfaces in parking lots of structures such as buildings.
- Points of attention in data interpretation are:

  - ✓ The decontamination effect may have large deviations because of deviations in decontamination conditions of high-pressure water washing at each decontamination place (nozzle elevations above ground surface, work time length per unit area and other conditions) and the size of the area to be decontaminated like parking lots or the different conditions of paved surfaces (permeability or drainage capability).
  - ✓ The reduction rate tends to be low when vehicles to restore permeable pavements are used with low water pressure and recirculated wastewater. Also, the cleaning and wastewater collection performance are downgraded on the road surfaces distorted or damaged by the earthquake and other reasons.

Measures should be taken to prevent wastewater from spreading, when decontaminating using water.

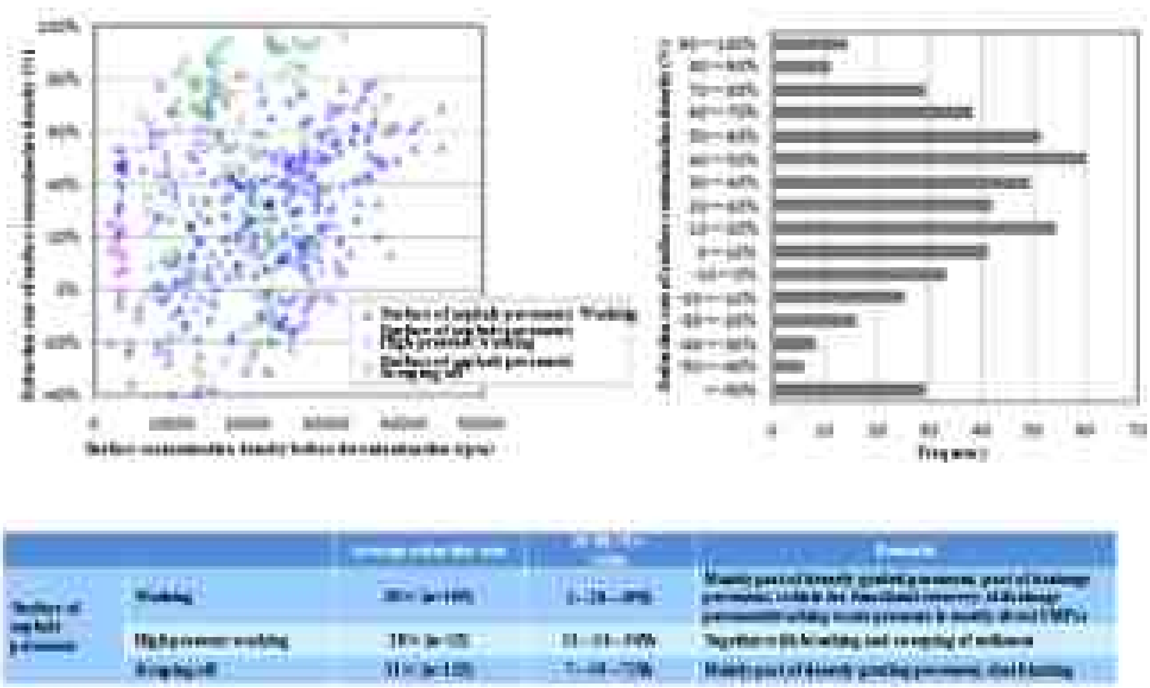


Figure 5-29 Decontamination effect for a target decontamination place (asphalt paved surfaces).

6. Outline of decontamination methods, applications and conditions thereof, and examination of the effects

Chapter 6.1 outlines the decontamination methods and their applications and conditions for the decontamination works in the Special Decontamination Area as directed by the Ministry of Environment (MOE). Chapter 6.2 shows some of the verification results of decontamination effects in the decontamination works executed.

The methods to apply and their conditions and the decontamination effects depend on various environmental conditions such as site situations, material properties and surface conditions of the objects subject to decontamination, and their aging variation with time. Therefore, the best decontamination methods and conditions are not easy to specify beforehand, even for a particular item to be decontaminated.

For example, the decontamination methods for the decontamination works have been changing with time after the accident. In the early stage, high-pressure water cleaning was effective in decontaminating paved road surfaces. But after some time, radioactive cesium has migrated from the surface deep into the materials so that scraping of the paved road surfaces by shot-blasting became a practical and effective approach, instead of simply washing the surfaces.

Meanwhile, weeds have grown in house gardens and on unpaved road surfaces as time elapsed after the accident. Also underbrush and shrubs have grown in farmland. Weed removal and underbrush/shrubs cutting are currently being added to the decontamination work, which had not been practiced in the early stage.

6.1. Outline of Decontamination Methods and Their Applications and Conditions

Outlines of decontamination methods, and their applications and conditions used in the decontamination works in the Special Decontamination Areas as directed by the MOE are given below.

Decontamination methods are specified in the Common Specifications of Decontamination Works ("Common Specifications" in this report) (7^{th} Edition), and this report summarizes the decontamination methods for each decontamination object shown in Table 6-1. As mentioned in Chapter 4.1.3 (4), the Common Specifications (7^{th} Edition) deals with not only (i) decontamination methods for reducing air dose rates, but also (ii) the methods for pre-decontamination works and post-decontamination works for restoration.

It should be noted that the amount of materials removed such as soil is not given in Chapter 6.1. It can be estimated, for instance, the reference soil thickness of about 5 cm set when scraping farmland (rice fields, dry fields, grassland) is multiplied by the size of the decontamination area (if the area of 100 m^2 is decontaminated by surface scraping, the soil to remove is estimated as 5 m^3). In actual cases, it is not possible to scrape the surface land uniformly. Uncertainties to some degree cannot be avoided. (See the case given later in Chapter 6.2.1-(4) 2) i).)

Table 6-1 Methods of decontamination for individual objects subject to decontamination

Classification of objects subject to decontamination		Classification of decontamination methods
Residential areas, schools, parks, large facilities, roads, etc.	sediments	sediment removal
	Roofs/ rooftops, exterior walls/outside walls, paved surfaces (concrete, asphalt) and the like of structures	wiping
		brush cleaning
		high-pressure water cleaning
		shot-blasting
		Superhigh pressure water cleaning
		Cleaning by road sweepers
	Weeds, lawns	Weeding, lawn mowing
		deep pruning of lawns
	Gravel, crushed stones	Removal of gravel, crushed stones
	Soil	Surface soil removal from rainwater guttering drains, and under-eaves
		Scraping of surface soil
		Soil surface covering
		Deep plowing
	Garden trees, planted vegetation and roadside trees	Surface soil removal from the bases of trees
		Delimbing of garden trees, planted vegetation, roadside trees
		Logging of garden trees, planted vegetation
	Others	Wiping, cleaning, scraping of playground equipment
		Removal of bottom sediments and the like in the street drains along the roads
Slopes		Removal of weeds, fallen leaves, and sediments from the slopes
Rice fields, dry fields, grassland, etc.	Weeds	Weeding the rice fields and dry fields by hands
		Weeding the rice fields and dry fields by machinery
		Collection of weeds removed from rice fields and dry fields
		Weeding the grassland
	Soil	Leveling of unevenness
		Spreading of surface solidification materials
		Scraping of surface soil (standard transfer method)
		Dual plowing
		Deep tillage
		Soil replacement
		Restoration of soil fertility
	Waterways	Removal of bottom sediments (soil sucking)
		Removal of bottom sediments (packing into bags)
	Others	Packing into bags (standard transfer method)
		Petit transfer on site (standard transfer method)
Grassland, lawns		Weeding (dense shrubs)
		Weeding (sparse shrubs)

Forests	Common items to the forests with mixed trees of coniferous evergreen trees, deciduous broad-leaf trees and others	Removal of deposited organic sediments
		Removal of deposited organic sediments (uncontrolled areas)
		Prevention of soil secondary dispersion (lining up of sandbags)
		Weeding underbrush and shrubs
		Removal of organic sediment residues
	Coniferous evergreen trees	Pruning of coniferous trees, collection of slips

6.1.1. Residential Areas, Schools, Parks, Large Facilities, Roads, etc.

（1） Sediment

1）Sediment removal

Locations to be decontaminated[137]	"1.1.1. Roofs (other than concrete)" of "1.1 Roofs/rooftops" in "1. Residential areas and the like" "1.1.2. Roofs (concrete)" of "1.1 Roofs/rooftops" in "1. Residential areas and the like" "1.3.1. Roof gutters" of "1.3 Rainwater gutters" in "1. Residential areas and the like" "1.4.1. Unpaved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like." "1.4.2. Paved surfaces" of "1.4. Gardens and the like." in "1. Residential areas and the like." "2.1. Roofs/rooftops" at "2. Schools" "2.3.1. Roof gutters" of "2.3. Rainwater gutters" at "2. Schools" "2.4.1. Sediment" of "2.4. School grounds and the like" at "2. Schools" "2.4.6. Paved surfaces" of "2.4. School grounds and the like" at "2. Schools" "3.1. Roofs/rooftops" in "3. Parks (small)" "3.3.1. Roof gutters" of "3.3. Rainwater gutters" in "3. Parks (small)" "3.4.1.Sediment" of "3.4. Playgrounds and the like" in "3. Parks (small)" "3.4.6.Paved surfaces" of "3.4. Playgrounds and the like" in "3. Parks (small)" "4.1. Roofs/rooftops" in 4. Parks (large)" "4.3.1. Roof gutters" of "4.3. Rainwater gutters" in "4. Parks (large)" "4.4.1.Sediment" of "4.4. Playgrounds and the like" in "4. Parks (large)" "4.4.6.Paved surfaces" of "4.4. Playgrounds and the like" in "4. Parks (large)" "5.1.1. Roofs/rooftops" of "5.1. Roofs/rooftops" of "5. Large facilities" "5.3.1. Roof gutters" of "5.3. Rainwater gutters" of "5. Large facilities" "5.4.1.Sediment" of "5.4. Playgrounds and the like" of "5. Large facilities" "5.4.6. Parking lots (concrete, asphalt)" of "5.4. Playgrounds and the like" of "5. Large facilities" "6.1.1. Sediment" of "6.1. Paved roads" of "6. Roads" "6.2.1. Road surfaces (soil)" of "6.2. Unpaved roads" of "6. Roads" "6.2.2. Road surfaces (gravel, crushed stone)" of "6.2. Unpaved roads" of "6. Roads" "6.5.1. Pedestrian overpasses" of "6.5. Pedestrian overpasses" "6. Roads" "6.6.1. Sediment" of "6.6. Roadside trees" of "6. Roads"
Decontamination methods	Sediment removal

[137] Residential areas and the like," "1.1 Roofs/rooftops," "1.1.1. Roofs (other than concrete)," etc. in the "Locations to be decontaminated," "Outline," and "Required equipment and materials" correspond to the objects subject to decontamination shown in Table 4-7 of the Common Specifications (7th Edition). The same source applies hereafter.

<table>
<tr><td>Outline</td><td>Sediment shall be removed in the following procedures
(i) Removing fallen leaves, moss, mud, etc.
(ii) Packing the removed materials
from roofs/rooftops, roof gutters, gardens, grounds, parking lots (concrete, asphalt), roads/sidewalks, pedestrian overpasses, roadside trees, etc. in residential areas, schools, parks, large facilities, roads, etc.</td></tr>
<tr><td>Decontamination processes</td><td>■ When working on
roofs/rooftops, gardens, etc. of residences, schools, parks (small), parks (large) or large facilities (1.1.1, 1.1.2, 1.4.1, 1.4.2, 2.1.1, 3.1.1, 4.1.1, 5.1.1);
grounds, paved surfaces, etc. of schools, parks (small), and parks (large) (2.4.1, 2.4.6, 3.4.1, 3.4.6, 4.4.1, 4.4.6); and
grounds of large facilities, parking lots (concrete, asphalt) (5.4.1, 5.4.6), paved and unpaved roads (6.1.1, 6.2.1, 6.2.2), as well as pedestrian overpasses (6.5.1) or roadside trees (6.6.1),
● Sediment such as fallen leaves, moss and mud shall be collected using rubber hand gloves, shovels, rakes, etc. and packed into large sandbags; and
● Sediment on easily broken roofs shall be removed with mops or the like, without getting directly on the roofs, by using aerial lift work vehicles and the like.
■ When working on roof gutters of residences, schools, parks (small), parks (large) or large facilities (1.3.1, 2.3.1, 3.3.1, 4.3.1, 5.3.1),
● Fallen leaves, moss, mud, etc. shall be removed using rubber hand gloves, brooms, brushes, etc. and packed into large sandbags.</td></tr>
<tr><td>Tools, equipment and the like for decontamination work</td><td>■ When working on
roofs/rooftops, gardens, etc. of residences, schools, parks (small), parks (large) or large facilities (1.1.1, 1.1.2, 1.4.1, 1.4.2, 2.1.1, 3.1.1, 4.1.1, 5.1.1);
grounds of parks (small), paved surfaces, etc. (3.4.1, 3.4.6); and
pedestrian overpasses (6.5.1), roadside trees (6.6.1),
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Rubber gloves, shovels, rakes, etc.</td><td>—</td></tr>
<tr><td>Large sandbags</td><td>—</td></tr>
</table>
*For the work at an elevated place, aerial lift work vehicles or scaffolds shall be used.</td></tr>
</table>

	■ When working on roof gutters of residences, schools, parks (small), parks (large) or large facilities (1.3.1, 2.3.1, 3.3.1, 4.3.1, 5.3.1), Tools, equipment to use — Quantity Rubber gloves, brooms, brushes, etc. — ― Large sandbags — ― ■ When working on grounds, paved surface, etc. of schools, parks (large) or large facilities (2.4.1,2.4.6, 4.4.1, 4.4.6); grounds, parking lots (concrete, asphalt) of large facilities (5.4.1, 5.4.5), and paved and unpaved roads (6.1.1, 6.2.1, 6.2.2), (per 1,300m^2) Tools, equipment to use — Quantity Rubber gloves, shovels, rakes, etc. — ― Dump trucks — 0.43 service days Light oil — 9.7L Large sandbags — ―
Workforce needed	■When working on roofs/rooftops, gardens, etc. of residences, schools, parks (small), parks (large) or large facilities (1.1.1, 1.1.2, 1.4.1, 1.4.2, 2.1.1, 3.1.1, 4.1.1, 5.1.1); grounds of parks (small), paved surfaces, etc. (3.4.1, 3.4.6); and pedestrian overpasses (6.5.1), roadside trees (6.6.1), (per 1,300m^2) Workforce needed — Quantity Operation leaders — 0.5 worker-days Decontamination workers — 3.2 worker-days ■ When working on roof gutters of residences, schools, parks (small), parks (large) or large facilities (1.3.1, 2.3.1, 3.3.1, 4.3.1, 5.3.1), (per 1,300m^2) Workforce needed — Quantity Operation leaders — 0.5 worker-days Decontamination workers — 3.2 worker-days

<table>
<tr><td colspan="2"></td><td>■ When working on
grounds, paved surface, etc. of schools, parks (large) or large facilities (2.4.1,2.4.6, 4.4.1, 4.4.6);
grounds, parking lots (concrete, asphalt) of large facilities (5.4.1, 5.4.5), and
paved and unpaved roads (6.1.1, 6.2.1, 6.2.2),
(per 1,300m²)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>0.5 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>3.2 worker-days</td></tr>
<tr><td>Drivers (ordinary decontamination)</td><td>0.37 worker-days</td></tr>
</table></td></tr>
<tr><td rowspan="5">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● In order to prevent contamination from spreading due to decontamination work, the order of tasks shall be considered. For instance, when decontaminating residential areas and the like, the decontamination work shall be done starting with roofs followed by rainwater gutters and then gardens and the like.
● When decontaminating for the first time after the accident at a certain place, sediment shall be checked as to whether the fallen leaves and the like are from after the accident or they were there at around the time of the accident.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Rubber gloves shall be worn.
● The removed objects shall be immediately packed to avoid unwanted exposure by contact.</td></tr>
<tr><td>General labor safety of workers</td><td>● For work at an elevated place, aerial lift work vehicles or scaffolds shall be used.
● For the work on roads, barricades and traffic controllers shall be arranged.</td></tr>
<tr><td>Measures to prevent secondary wastes</td><td>–</td></tr>
<tr><td>Others</td><td>–</td></tr>
</table>

（2） Roofs/rooftops, exterior walls, outside walls, paved surfaces (concrete, asphalt), etc. of structures

1）Wiping

Locations to be decontaminated	"1.1.1. Roofs (other than concrete)" of "1.1 Roofs/rooftops" in "1. "Residential areas and the like" "1.1.2. Roofs (concrete)" of "1.1 Roofs/rooftops" in "1. Residential areas and the like" "1.2.1. Other than earthen walls" of "1.2. Exterior walls/outside walls" in "1. Residential areas and the like" "1.2.2. Earthen walls" of "1.2. Exterior walls/outside walls" in "1. Residential areas and the like" "1.3.1. Roof gutters" of "1.3 Rainwater gutters" in "1. Residential areas and the like" "2.1. Roofs/rooftops" at "2. Schools" "2.2. Exterior walls/outside walls" at "2. Schools" "2.3.1. Roof gutters" of "2.3. Rainwater gutters" at "2. Schools" "3.1. Roofs/rooftops" in "3. Parks (small)" "3.2.1. Exterior walls/outside walls" of "3.2. Exterior walls/outside walls" in "3. Parks (small)" "3.3.1. Roof gutters" of "3.3. Rainwater gutters" in "3. Parks (small)" "4.1. Roofs/rooftops" in "4. Parks (large)" "4.2.1. Exterior walls/outside walls" of "4.2. Exterior walls/outside walls" in "4. Parks (large)" "4.3.1. Roof gutters" of "4.3. Rainwater gutters" in "4. Parks (large)" "5.1.1. Roofs/rooftops" of "5.1. Roofs/rooftops" of "5. Large facilities" "5.2.1. Exterior walls/outside walls" of "5.2. Exterior walls/outside walls" of "5. Large facilities" "5.3.1. Roof gutters" of "5.3. Rainwater gutters" of "5. Large facilities" "6.3.1. Guardrails" of "6.3.Guardrails" of "6. Roads" "6.5.1. Pedestrian overpasses" of "6.5. Pedestrian overpasses" of "6. Roads"
Decontamination methods	Wiping

Outline	Roofs/rooftops, exterior walls/outside walls, roof gutters, guardrails, pedestrian overpasses, etc. in residential areas, schools, parks, large facilities, etc. shall be decontaminated through wiping.
Decontamination processes	● The objects to be decontaminated shall be carefully wiped by using cleaning cloths and the like moistened with water or the like (including neutral detergents or vinegar). In wiping, their folded clean faces shall be used until repeated wiping gives hardly any further reduction in the surface contamination density.
Tools, equipment and the like for	

<table>
<tr><td colspan="2">decontamination work</td><td>

Tools, equipment to use	Quantity
Cleaning cloths and the like	—
Brushes (including deck brushes, car washing brushes)	—

* For the work at elevated places, adequate safety measures shall be taken for scaffolds, aerial lift work vehicles and fall arresting devices/systems using fixed ropes/safety belts, etc.
</td></tr>
<tr><td colspan="2">Workforce needed</td><td>

■ When working on roofs/rooftops (1.1.1, 1.1.2, 2.1.1, 3.1.1, 4.1.1, 5.1.1) of residential areas, schools, parks (small), parks (large), large facilities, etc. and pedestrian overpasses (6.5.1),

(per 130m²)

Workforce needed	Quantity
Operation leaders	0.3 worker-days
Decontamination workers	2.2 worker-days

■ When working on exterior walls/outside walls (1.2.1, 1.2.2, 2.2.1, 3.2.1, 4.2.1, 5.2.1) of residential areas, schools, parks (small), parks (large), large facilities, etc.,

(per 1,300m²)

Workforce needed	Quantity
Operation leaders	2.6 worker-days
Decontamination workers	17.2 worker-days

■ When working on roof gutters (1.3.1, 2.3.1, 3.3.1, 4.3.1, 5.3.1) of residential areas, schools, parks (small), parks (large), large facilities, etc.,

(per 130m)

Workforce needed	Quantity
Operation leaders	0.2 worker-days
Decontamination workers	1.1 worker-days

■ When working on guard rails (6.3.1),

(per 100m)

Workforce needed	Quantity
Operation leaders	0.1 worker-days
Decontamination workers	0.8 worker-days
</td></tr>
<tr><td>Idea development, lessons,</td><td>Prerequisites and constraints regarding objects and locations</td><td>

● In order to prevent contamination from spreading due to decontamination work, wiping shall be done from top to bottom, for
</td></tr>
</table>

points to keep in mind, etc.	to be decontaminated	instance, when wiping residential areas and the like, starting with roofs first followed by rainwater gutters and the like. ● Surfaces with attached materials like moss or mud which are difficult to remove by wiping, or clearly visible dirty surfaces shall be decontaminated by carefully removing the attached dirt using brushes with dry conditions without damaging the objects. ● Folded clean faces of the cleaning cloths shall be used for each wiping step, in order to prevent contaminants being reattached to the surfaces. ● When decontaminating earthen walls, brushes and the like shall be used, not cleaning cloths and the like, to remove dirt with dry conditions without damaging the objects. ● When decontaminating exterior walls/outside walls other than earthen walls, or when decontaminating guardrails, brushes (including car washing brushes, deck brushes) and the like shall be used to remove dirt with dry conditions without damaging the objects. Surfaces with attached materials like moss or mud which are difficult to remove, or clearly visible dirty surfaces shall be decontaminated by carefully removing the attached dirt using metal brushes or brushes moistened with water or the like without damaging the objects. ● When decontaminating pedestrian overpasses, their handrails shall be decontaminated through wiping. ● When rust is present, the rust itself shall be removed through wiping and other means.
	Radiation exposure protection of workers	● Hand gloves and the like shall be worn. ● Cleaning cloths and the like shall not be directly touched, because they might be contaminated by radiocesium.
	General labor safety of workers	● For the work at elevated places, adequate safety measures shall be taken for scaffolds, aerial lift work vehicles and fall arresting devices/systems using fixed ropes/safety belts and the like. ● For the work on roads, barricades and traffic controllers shall be arranged.
	Measures to prevent secondary wastes	–
	Others	–

2）Brush cleaning

Locations to be decontaminated	"1.1.1. Roofs (other than concrete)" of "1.1 Roofs/rooftops" in "1. Residential areas and the like" "1.1.2. Roofs (concrete)" of "1.1 Roofs/rooftops" in "1. Residential areas and the like" "1.2.1. Other than earthen walls" of "1.2. Exterior walls/outside walls" in "1. Residential areas and the like" "1.4.2. Paved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like" "2.1. Roofs/rooftops" at "2. Schools" "2.2. Exterior walls/outside walls" at "2. Schools" "2.4.6 Paved surfaces" of "2.4. Grounds and the like" at "2. Schools" "3.1. Roofs/rooftops" in "3. Parks (small)" "3.2.1. Exterior walls/outside walls" of "3.2. Exterior walls/outside walls" in "3. Parks (small)" "3.4.6. Paved surfaces" of "3.4. Grounds and the like" in "3. Parks (small)" "4.1. Roofs/rooftops" in "4. Parks (large)" "4.2.1. Exterior walls/outside walls" of "4.2. Exterior walls/outside walls" in "4. Parks (large)" "4.4.6. Paved surfaces" of "4.4. Grounds and the like" in "4. Parks (large)" "5.1.1. Roofs/rooftops" of "5.1. Roofs/rooftops" of "5. Large facilities" "5.2.1. Exterior walls/outside walls" of "5.2. Exterior walls/outside walls" of "5. Large facilities" "5.4.6. Parking lots (concrete, asphalt)" of "5.4. Grounds and the like" of "5. Large facilities" "6.3.1. Guardrails" of "6.3.Guardrails" of "6. Roads" "6.5.1. Pedestrian overpasses" of "6.5. Pedestrian overpasses" of "6. Roads"
Decontamination methods	Brush cleaning

Outline	Roofs/rooftops and exterior walls/ outside walls in residential areas, schools, parks and large facilities, paved surfaces of gardens, grounds and the like, parking lots (concrete, asphalt), guardrails, pedestrian overpasses, etc. shall be cleaned using brushes in the following procedures (i) Cleaning using brushes (ii) Collecting used water
Decontamination processes	● Cleaning by deck brushes or scrubbing brushes shall be repeated carefully until there is hardly any further reduction in the surface contamination densities. ● About 4L/m^2 of water shall be poured on surfaces before brushing and also after

<table>
<tr><td></td><td>brushing for washing.
● The cleaning water discharge lines shall be cleaned beforehand for smooth discharge. The discharge shall be collected in rainwater cisterns and the like. After collection, it shall be transferred to on-site or nearby wastewater treatment facilities.</td></tr>
<tr><td>Tools, equipment and the like for decontamination work</td><td>
■ When working on roofs/rooftops of residences, schools, parks (small), parks (large) or large facilities (1.1.1, 1.1.2, 2.1.1, 3.1.1, 4.1.1, 5.1.1),
(per 130m²)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Deck brushes, scrubbing brushes, etc.</td><td>—</td></tr>
<tr><td>Sprinkler trucks (tank capacity 3,800L)</td><td>0.6 service days</td></tr>
<tr><td>Light oil</td><td>9.9L</td></tr>
<tr><td>Water</td><td>0.5m³</td></tr>
<tr><td>Temporary systems and the like for wastewater collection</td><td>—</td></tr>
</table>
* For the work at elevated places, adequate safety measures shall be taken for scaffolds, aerial lift work vehicles and fall arresting devices/systems using fixed ropes/safety belts, etc.

■ When working on exterior walls/outside walls other than earthen walls of residences and the like (1,2,1), exterior walls/outside walls of schools, parks (small), parks (large), large facilities, etc. (2.2.1, 3.2.1, 4.2.1, 5.2.1), paved surfaces of grounds and the like, of residences and the like, schools, parks (small) and parks (large), parking lots (concrete, asphalt) of large facilities (5.4.6) and pedestrian overpasses (6.5.1),
(per 1,300m²)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Deck brushes, scrubbing brushes, etc.</td><td>—</td></tr>
<tr><td>Water</td><td>5m³</td></tr>
<tr><td>Temporary systems and the like for wastewater collection</td><td>—</td></tr>
</table>
* For the work at elevated places, aerial lift work vehicles and scaffolds shall be used.

■ When working on guardrails (6.3.1),
(per 1,900m)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Deck brushes, scrubbing brushes, etc.</td><td>—</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td colspan="2"></td><td>
<table>
<tr><td>Water</td><td>5m^3</td></tr>
<tr><td>Temporary systems and the like for wastewater collection</td><td>—</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Workforce needed</td><td>
■ When working on roofs/rooftops of residences, schools, parks (small), parks (large) or large facilities (1.1.1, 1.1.2, 2.1.1, 3.1.1, 4.1.1, 5.1.1),
(per 130 m^2)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>0.6 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>3.6 worker-days</td></tr>
<tr><td>Drivers (ordinary decontamination)</td><td>0.4 worker-days</td></tr>
</table>
■ ■When working on exterior walls/outside walls other than earthen walls of residences and the like (1,2,1), exterior walls/outside walls of schools, parks (small), parks (large), large facilities, etc. (2.2.1, 3.2.1, 4.2.1, 5.2.1), paved surfaces of grounds and the like, of residences and the like, schools, parks (small) and parks (large) (1.4.2, 2.4.6, 3.4.6, 4.4.6), parking lots (concrete, asphalt) of large facilities (5.4.6) and pedestrian overpasses,
(per 1,300m^2)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>4.2 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>28.1 worker-days</td></tr>
</table>
■ When working on guardrails (6.3.1),
(per 1,900m)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>4.2 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>28.1 worker-days</td></tr>
</table>
</td></tr>
<tr><td>Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>
● Brush cleaning shall be done from top to bottom in order to prevent contamination from spreading due to decontamination work, for instance, when cleaning residential areas and the like, starting with roofs first followed by exterior walls, gardens, etc.
● Cleaning shall be done from above in order to avoid water being scattered.
</td></tr>
</table>

		● Rotary brushes shall not be used when decontaminating thatched roofs or tiled roofs, as they are not suitable for such materials. ● When decontaminating pedestrian overpasses, their handrails shall be cleaned with brushes.
	Radiation exposure protection of workers	● Rubber hand gloves, dust masks and other protective gear shall be worn.
	General labor safety of workers	● For the work at elevated places, adequate safety measures shall be taken for scaffolds, aerial lift work vehicles and fall arresting devices/systems using fixed ropes/safety belts, etc. ● For the work on roads, barricades and traffic controllers shall be arranged.
	Measures to prevent secondary wastes	–
	Others	–

3）High-pressure water cleaning

Locations to be decontaminated	“1.3.1. Roof gutters” of “1.3 Rainwater gutters” in “1. Residential areas and the like” “1.3.2. Rainwater pipes” of “1.3 Rainwater gutters” in “1. Residential areas and the like” “1.4.2. Paved surfaces” of “1.4. Gardens and the like” in “1. Residential areas and the like” “2.1. Roofs/rooftops” at “2. Schools” “2.2. Exterior walls/outside walls” at “2. Schools” “2.3.1. Roof gutters” of “2.3. Rainwater gutters” at “2. Schools” “2.3.2 Rainwater pipes” of “2.3. Rainwater gutters” at “2. Schools” “2.4.6. Paved surfaces” of “2.4. Grounds and the like” at “2. Schools” “3.1. Roofs/rooftops” in “3. Parks (small)” “3.2.1 Exterior walls/outside walls” of “3.2. Exterior walls/outside walls” in “3. Parks (small)” “3.3.1. Roof gutters” of “3.3. Rainwater gutters” in “3. Parks (small)” “3.3.2. Rainwater pipes” of “3.3. Rainwater gutters” in “3. Parks (small)” “3.4.6.Paved surfaces” of “3.4. Playgrounds and the like” in “3. Parks (small)” “4.1. Roofs/rooftops” in “4. Parks (large)” “4.2.1 Exterior walls/outside walls” of “4.2. Exterior walls/outside walls” in “4. Parks (large)” “4.3.1. Roof gutters” of “4.3. Rainwater gutters” in “4. Parks (large)” “4.3.2. Rainwater pipes” of “4.3. Rainwater gutters” in “4. Parks (large)” “4.4.6.Paved surfaces” of “4.4. Playgrounds and the like” in “4. Parks (large)” “5.1.1. Roofs/rooftops” of “5.1. Roofs/rooftops” of “5. Large facilities” “5.2.1 Exterior walls/outside walls” of “5.2. Exterior walls/outside walls” of “5. Large facilities” “5.3.1.” of “5.3. Rainwater gutters” of “5. Large facilities” “5.3.2. Rainwater pipes” of “5.3. Rainwater gutters” of “5. Large facilities” “5.4.6. Parking lots (concrete, asphalt)” of “5.4. Playgrounds and the like” of “5. Large facilities” “6.1.2. Roads/Sidewalks” of “6.1. Paved roads” of “6. Roads” “6.3.1. Guardrails” of “6.3. Guardrails” of “6. Roads” “6.5.1. Pedestrian overpasses” of “6.5. Pedestrian overpasses” of “6. Roads”
Decontamination methods	High-pressure water cleaning

Outline	Roofs/rooftops, exterior walls/ outside walls, rainwater gutters (roof gutters, rainwater pipes) in the residential areas, schools, parks and large facilities; grounds and the like (paved surfaces); parking lots (concrete, asphalt); and paved roads/sidewalks, guardrails, and pedestrian overpasses shall be cleaned by using high-pressure water cleaning in the following procedures

	(i) Cleaning by using high-pressure water cleaners (ii) Collecting waste water
Decontamination processes	■When working on roof gutters of residences and the like, schools, parks (small), parks (large) and large facilities (1.3.1, 2.3.1, 3.3.1, 4.3.1, 5.3.1) ● The cleaning water discharge lines shall be cleaned beforehand for smooth discharge. The discharge shall be collected in rainwater cisterns or the like. After collection, it shall be transferred to on-site or nearby wastewater treatment facilities. ● High-pressure water cleaning shall be applied mainly where, for instance, it is too narrow for a hand to reach for wiping. High-pressure water of about 2 L/min below 5 MPa in principle shall be sprayed by using high-pressure water cleaners, with attention to avoid damaging rainwater gutters. ● The spray nozzle shall be brought near the objects to be cleaned (about 20 cm) at an appropriate moving speed for achieving the cleaning effect. ● The water cleaning shall be done from the upper stream to the lower stream of gradients to avoid water scattering to the surroundings. ■When working on rainwater pipes of residences and the like, schools, parks (small), parks (large) and large facilities (1.3.2, 2.3.2, 3.3.2, 4.3.2, 5.3.2), ● Sediment, if any, shall be removed before the cleaning. ● The cleaning water discharge lines shall be cleaned beforehand for smooth discharge. The discharge shall be collected in rainwater cisterns and the like. After collection, it shall be transferred to on-site or nearby wastewater treatment facilities. ● High-pressure water of about 2 L/min below 5 MPa in principle shall be sprayed by using high-pressure water cleaners, with attention to avoid damaging rainwater gutters. ■When working on paved surfaces in the gardens and the like of residences and the like, grounds and the like of parks (small), and pedestrian overpasses (1.4.2, 3.4.6, 6.5.1); paved surfaces of the grounds and the like at schools and parks (large), parking lots (concrete, asphalt) of large facilities, and paved roads/sidewalks (2.4.6, 4.4.6, 5.4.6, 6.1.2), ● High-pressure water of about 20 MPa in

	principle shall be sprayed in about 20 L/m^2 by using suction-type high-pressure water cleaners. ● The cleaning water collected shall be transferred to on-site or nearby wastewater treatment facilities. ● The water cleaning shall be done from peripheries to inner sides and from the upper stream to the lower stream of gradients to avoid water scattering to the surrounding. ● The cleaning shall be done in a shielded environment in order to avoid water scattering when buildings stand closely next to each other. ■ When working on roofs/rooftops of schools, parks (small), parks (large) and large facilities (2.1.1, 3.1.1, 4.1.1, 5.1.1), ● The cleaning water discharge lines shall be cleaned beforehand for smooth discharge. The discharge shall be collected in rainwater cisterns and the like. After collection, it shall be transferred to on-site or nearby wastewater treatment facilities. ● High-pressure water of about 15 MPa in principle shall be sprayed in about 20 L/m^2 using high-pressure water cleaners. ● The spray nozzle shall be brought near the objects to be cleaned (about 20cm) at an appropriate moving speed for achieving the cleaning effect. ● The water cleaning shall be done from peripheries to inner sides and from the upper stream to the lower stream of gradients to avoid water scattering to the surrounding. ● The cleaning shall be done in a shielded environment by using sheets or the like in order to avoid water scattering. ● Attention shall be paid to protect water-proof paints or water-proof sheets from damage. ■When working on exterior walls/outside walls of schools, parks (small), parks (large) and large facilities (2.2.1, 3.2.1, 4.2.1, 5.2.1), or guardrails of roads (6.3.1), ● The cleaning water discharge lines shall be cleaned beforehand for smooth discharge. The discharge shall be collected in rainwater cisterns and the like. After collection, it shall be transferred to on-site or nearby wastewater treatment facilities. ● High-pressure water of about 15 MPa in principle shall be sprayed in about 20 L/m^2 using high-pressure water cleaners.

	● The spray nozzle shall be brought near the objects to be cleaned (about 20 cm) at an appropriate moving speed for achieving the cleaning effect. ● The water cleaning shall be done from peripheries to inner sides and from the upper stream to the lower stream of gradients to avoid water scattering to the surrounding.
Tools, equipment and the like for decontamination work	■When working on roof gutters of residences and the like, schools, parks (small), parks (large) and large facilities (1.3.1, 2.3.1, 3.3.1, 4.3.1, 5.3.1) (per 130m)

Tools, equipment to use	Quantity
Sprinkler trucks (Tank capacity 3,800L)	0.6 service days
High-pressure cleaners (Motor-driven, Output 3.7kw)	1.9 service days
Engine generators (rated 17/20kvA, exhaust gas suppression type (primary side))	1.9 service days
Light oil	36.4 L
Water	0.3 m^3
Temporary systems and the like for wastewater collection	—

■When working on rainwater pipes of residences and the like, schools, parks (small), parks (large) and large facilities (1.3.2, 2.3.2, 3.3.2, 4.3.2, 5.3.2), (per 130m)

Tools, equipment to use	Quantity
Sprinkler trucks (Tank capacity 3,800 L)	1.7 service days
High-pressure cleaners (Motor-driven, Output 3.7 kw)	1.4 service days
Engine generators (rated 17/20 kvA, exhaust gas suppression type (primary side))	1.4 service days
Light oil	46.1 L
Water	0.3 m^3
Temporary systems and the like for wastewater collection	—

■When working on paved surfaces in the gardens and the like of residences and the like and parks (small), pedestrian overpasses (1.4.2, 3.4.6, 6.5.1), (per 300 m^2)

Tools, equipment to use	Quantity
Suction-type high-pressure cleaners (discharge pressure 20.5MPa, vacuum pump)	1 service day

Rotary-type water collecting vehicles (φ 300)	1 service day
Sprinkler trucks (tank capacity 3,800L)	1 service day
Crane trucks (load capacity 2 t, suspension weight 2.9 t)	1 service day
Sewage filters (200 L)	1 service day
Sewage tank (1 m^3 polyethylene)	6 service days
Feedwater tank (1 m^3 polyethylene)	1 service day
Light oil	53.3 L
Water	6 m^3

■ When working on roofs/rooftops of schools, parks (small), parks (large) and large facilities (2.1.1, 3.1.1, 4.1.1, 5.1.1),

(per 1,300 m^2)

Tools, equipment to use	Quantity
High-pressure cleaners (Engine-driven, output 18 kw)	4.2 service days
Street drain cleaner (Blower-type, hopper capacity 3.1m^3, air-flow 20m^3/min)	4 service days
Sprinkler trucks (tank capacity 3,800 L)	4.9 service days
Engine-generators (Rated 17/20 kvA, exhaust gas suppression type (primary side))	4.2 service days
Submersible motor pumps for construction work (50 mm caliber, total head 20 m)	4.2 service days
Water tanks (for general construction work, 3 m^3)	4.2 service days
Light oil	196.2 L
Water	27 m^3
Temporary systems and the like for wastewater collection	—

■When working on exterior walls/outside walls of schools, parks (small), parks (large) and large facilities (2.2.1, 3.2.1, 4.2.1, 5.2.1),

(per 1,300 m^2)

Tools, equipment to use	Quantity
High-pressure cleaners (Engine-driven, output 18kw)	4.2 service days
Street drain cleaners (Blower-type, hopper capacity 3.1 m^3, air-flow 20 m^3/min)	4 service days

		Sprinkler trucks (tank capacity 3,800 L)	4.9 service days
		Light oil	183.9 L
		Water	27 m^3
		Temporary systems and the like for wastewater collection	—

■When working on paved surfaces in the school grounds and the like and parks (large), parking lots (concrete, asphalt) of large facilities, and paved roads/sidewalks (2.4.6, 4.4.6, 5.4.6, 6.1.2),

(per 350 m^2)

Tools, equipment to use	Quantity
Suction-type high-pressure water cleaners (discharge pressure 20.5 MPa, vacuum pump)	1 service day
Rotary-type water collecting vehicles (ϕ 450)	1 service day
Sprinkler trucks (tank capacity 3,800L)	1 service day
Crane trucks (load capacity 2t, suspension weight 2.9t)	1 service day
Sewage filters (200 L)	1 service day
Sewage tank (1 m^3 polyethylene)	7 service days
Feedwater tank (1 m^3 polyethylene)	1 service day
Light oil	53.3 L
Water	7 m^3

■When working on road guardrails (6.3.1),

(per 1,900 m)

Tools, equipment to use	Quantity
High-pressure cleaners (Engine-driven, output 18 kw)	4.2 service days
Street drain cleaners (Blower-type, hopper capacity 3.1 m^3, air-flow 20 m^3/min)	4 service days
Sprinkler trucks (tank capacity 3,800 L)	4.9 service days
Light oil	183.1 L
Water	27 m^3
Temporary systems and the like for wastewater collection	—

Workforce needed

■When working on roof gutters of residences and the like, schools, parks (small), parks (large) and large facilities (1.3.1, 2.3.1, 3.3.1, 4.3.1, 5.3.1)

(per 130 m)

Workforce needed	Quantity
Operation leaders	0.4 worker-days
Decontamination workers	2.1 worker-days
Drivers (ordinary decontamination)	0.4 worker-days

■When working on rainwater pipes of residences and the like, schools, parks (small), parks (large) and large facilities (1.3.2, 2.3.2, 3.3.2, 4.3.2, 5.3.2)

(per 130 m)

Workforce needed	Quantity
Operation leaders	0.5 worker-days
Decontamination workers	2.2 worker-days
Drivers (ordinary decontamination)	1.1 worker-days

■When working on paved surfaces in the gardens and the like of residences and the like and parks (small), pedestrian overpasses (1.4.2, 3.4.6, 6.5.1),

(per 300 m^2)

Workforce needed	Quantity
Operation leaders	1.0 worker-day
Specialized decontamination workers	1.0 worker-day
Decontamination workers	3.0 worker-days
Drivers (ordinary decontamination)	1.0 worker-day

■ When working on roofs/rooftops of schools, parks (small), parks (large) and large facilities (2.1.1, 3.1.1, 4.1.1, 5.1.1), exterior walls/outside walls of schools, parks (small), parks (large) and large facilities (2.2.1, 3.2.1, 4.2.1, 5.2.1),

(per 1,300 m^2)

Workforce needed	Quantity
Operation leaders	2.1 worker-days
Decontamination workers	7.9 worker-days
Drivers (ordinary decontamination)	6.2 worker-days

■When working on paved surfaces in the school grounds and the like and parks (large), parking lots (concrete, asphalt) of large facilities, and

<table>
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paved roads/sidewalks (2.4.6, 4.4.6, 5.4.6, 6.1.2),
(per 350 m^2)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>1.0 worker-day</td></tr>
<tr><td>Specialized decontamination workers</td><td>1.0 worker-day</td></tr>
<tr><td>Decontamination workers</td><td>3.0 worker-days</td></tr>
<tr><td>Drivers (ordinary decontamination)</td><td>1.0 worker-day</td></tr>
</table>
■When working on road guardrails (6.3.1),
(per 1,900 m)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>2.1 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>7.9 worker-days</td></tr>
<tr><td>Drivers (ordinary decontamination)</td><td>6.2 worker-days</td></tr>
</table>
</td>
</tr>
<tr>
<td>Idea development, lessons, points to keep in mind, etc.</td>
<td>Prerequisites and constraints regarding objects and locations to be decontaminated</td>
<td>

In order to prevent contamination from spreading due to decontamination work, the order of works shall be considered. For instance, when decontaminating residential areas and the like, the decontamination work shall be done starting with roofs followed by rainwater gutters and then gardens and the like. If residences and the like stand closely next to each other, the cleaning shall be done in a shielded environment by using sheets and the like in order to avoid water scattering over surrounding residences and the like.
No risk of damaging the objects by high-pressure water cleaning shall be checked beforehand. Attention shall be paid to the possibility of damaging objects by stripping off the surface.
Soil shall be cleaned at low pressures first in order to prevent soil dispersion. The pressure shall be increased gradually by confirming the cleaning water flows and dispersion conditions.
Special attention shall be paid when cleaning the overlapping sections of roofs, places where the metal is corroded, and around the drains for rooftops. At these places large amounts of sediment are attached.
Paved surfaces shall not be cleaned when frozen or snow covered.
Suction-type high-pressure water cleaners shall be used when cleaning paved surfaces of gardens and the like of residences and the

</td>
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</table>

		like, grounds and the like, of parks (small), pedestrian overpasses (1.4.2, 3.4.6, 6.5.1), those of school grounds and the like, parks (large), parking lots (concrete, asphalt) of large facilities, or paved roads/sidewalks (2.4.6, 4.4.6, 5.4.6, 6.1.2). When cleaning other objects, the discharge water shall be collected in the rainwater cisterns and the like. ● Cleaning conditions for decontaminating respective objects shall be as follows in principle.
	Radiation exposure protection of workers	● Safety glasses, dust masks, hand gloves, etc. shall be worn
	General labor safety of workers	● For the work at elevated places, adequate safety measures shall be taken for scaffolds, aerial lift work vehicles and fall arresting devices/systems using fixed ropes/safety belts, etc. ● For the work on roads, barricades and traffic

Objects to be decontaminated	Conditions (principle)
Roof gutters (1.3.1, 2.3.1, 3.3.1, 4.3.1, 5.3.1) and rainwater pipes (1.3.2, 2.3.2, 3.3.2, 4.3.2, 5.3.2) of residences and the like, schools, parks (small), parks (large) and large facilities	Cleaning with high pressure water of about 5 MPa in about 2 L/m², in principle, by using a high-pressure water cleaner
Roofs/rooftops (2.1.1, 3.1.1, 4.1.1, 5.1.1) and exterior walls/outside walls (2.2.1, 3.2.1, 4.2.1, 5.2.1) of schools, parks (small), parks (large), and large facilities, and road guardrails (6.3.1)	Cleaning with high pressure water of about 15 MPa in about 20 L/m², in principle, by using a high-pressure water cleaner
Paved surfaces of gardens and the like of residences and the like, grounds of parks (small), and pedestrian overpasses (1.4.2, 3.4.6, 6.5.1), those of school grounds and the like, parks (large), parking lots (concrete, asphalt) of large facilities, and paved roads/sidewalks (2.4.6, 4.4.6, 5.4.6, 6.1.2)	Cleaning with high pressure water of about 20 MPa in about 20 L/m², in principle, by using a suction-type high-pressure water cleaner

		controllers shall be arranged.
	Measures to prevent secondary wastes	−
	Others	−

4）Shot-blasting

Locations to be decontaminated	"1.4.2. Paved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like" "2.4.6. Paved surfaces" of "2.4. Grounds and the like" at "2. Schools" "3.4.6.Paved surfaces" of "3.4. Grounds and the like" in "3. Parks (small)" "4.4.6.Paved surfaces" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.6. Parking lots (concrete, asphalt)" of "5.4. Grounds and the like" of "5. Large facilities" "6.1.2. Roads/Sidewalks" of "6.1. Paved roads" of "6. Roads"
Decontamination methods	Shot-blasting

Outline	Paved surfaces of gardens/grounds in the residential areas, schools, parks and large facilities, etc.,, parking lots (concrete, asphalt), and paved roads/sidewalks shall be cleaned by shot-blasting in the following procedures (i) Scraping off object surfaces with shot-blasters (ii) Packing scrapped materials
Decontamination processes	● Scraping shall be done in a fairly wide paved place. ● Abrasive materials such as steel shot shall be shot on the surface with a shot-blaster for scraping away the said surface uniformly. ● Scrapped materials, asphalt and the like, shall be collected by a dust collector connected to the shot-blaster. ● Collected scrapped materials shall be packed in large sandbags. ● Fine particles generated shall be prevented from dispersion to the surroundings by covers and shall be collected. ● A small amount of abrasive materials left behind on the surfaces shall be collected by a manual magnet car and cleaning.
Tools, equipment and the like for decontamination work	■When working on paved surfaces of gardens and the like, of residences and the like (1.4.2), (per 350 m²) Tools, equipment to use: Quantity Shot-blasters (scraping/ suction width 700 mm): 6.5 service hours Engine-generators (Rated 100/125 kvA, exhaust gas suppression type (primary side)): 1.09 service days

Dust collectors (suction width 700/1000 mm, wind velocity 75 m^3)	6.5 service hours
Crane trucks (load capacity 4 t, suspension weight 2.9 t)	1.23 service days
Trucks (load capacity 4 t)	1.13 service days
Light oil	192 L
Large sandbags	-

■ When working on paved surfaces in the grounds of schools, parks (small), and parks (large) (2.4.6, 3.4.6, 4.4.6,), parking lots (concrete, asphalt) of large facilities (5.4.6), and paved roads/sidewalks (6.1.2),

(per 500 m^2)

Tools, equipment to use	Quantity
Shot-blasters (scraping/ suction width 1,000 mm)	6.5 service hours
Engine-generators (Rated 125/150 kvA, exhaust gas suppression type (primary side))	1.03 service days
Dust collectors (suction width 700/1000 mm, wind velocity 75 m^3)	6.5 service hours
Crane trucks (load capacity 8 t, suspension weight 2.9 t)	1.23 service days
Trucks (load capacity 8 t)	1.13 service days
Light oil	255 L
Large sandbags	-

Workforce needed

■When working on paved surfaces of gardens and the like, of residences and the like (1.4.2),

(per 350 m^2)

Workforce needed	Quantity
Operation leader	1.0 worker-day
Decontamination worker	2.0 worker-days
Driver (special decontamination)	2.0 worker-days
Driver (ordinary decontamination)	1.0 worker-day

■ When working on paved surfaces in the grounds of schools, parks (small), and parks (large) (2.4.6, 3.4.6, 4.4.6,), parking lots

<table>
<tr><td colspan="2"></td><td>(concrete, asphalt) of large facilities (5.4.6), and paved roads/sidewalks (6.1.2),
(per 500 m²)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leader</td><td>1.0 worker-day</td></tr>
<tr><td>Decontamination worker</td><td>2.0 worker-days</td></tr>
<tr><td>Driver (special decontamination)</td><td>2.0 worker-days</td></tr>
<tr><td>Driver (ordinary decontamination)</td><td>1.0 worker-day</td></tr>
</table></td></tr>
<tr><td rowspan="5">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Paved surfaces shall not be cleaned when frozen or snow covered.
● Work shall be halted when raining or roads are wet because working and collecting of scrapped materials is difficult.
● It should be noted that the decontamination effect by scraping is lowered when ruts or cracks are present on the paved surfaces relative to smooth surfaces.
● This cleaning method is not effective when the road unevenness or crack depths exceed 5 mm.
● At the edges of blasted area, 5 – 10 cm overlapping is needed for removing surface irregularity.
● High-pressure water cleaning and the like shall be used in place of the shot-blasting method at the edges of paved surfaces 15 – 30 cm from adjacent buildings or other structures.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Safety glasses, dust masks, hand gloves, etc. shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>● For the work on roads, barricades and traffic controllers shall be arranged.</td></tr>
<tr><td>Measures to prevent secondary wastes</td><td>–</td></tr>
<tr><td>Others</td><td>● For the work in narrow spaces of less than about 10 m² of paved surfaces in residential areas, unit space of 350 m² shall be read as 50 m² (tools, equipment, workforce needed).</td></tr>
</table>

5）Superhigh pressure water cleaning

Locations to be decontaminated	"2.4.6. Paved surfaces" of "2.4. Grounds and the like" at "2. Schools" "4.4.6.Paved surfaces" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.6. Parking lots (concrete, asphalt)" of "5.4. Grounds and the like" of "5. Large facilities" "6.1.2. Roads/Sidewalks" of "6.1. Paved roads" of "6. Roads"
Decontamination methods	Superhigh pressure water cleaning

Outline	Paved surfaces of schools, parks (large) and large facilities, parking lots (concrete, asphalt), and paved roads/sidewalks shall be cleaned by superhigh pressure water in the following procedures (i) Scraping off object surfaces with super high-pressure water cleaners (ii) Collecting wastewater from decontamination
Decontamination processes	● Paved surfaces shall be scraped off by about 5mm with superhigh pressure water cleaners (cleaning water recovery-type) of 150 MPa or higher. ● Wastewater collected shall be separated to scrapings (sludge) and water by the coagulating sedimentation process, or other means.
Tools, equipment and the like for decontamination work	(per 1,300 m^2)

Tools, equipment to use	Quantity
Shovels , brooms and the like	-
Superhigh pressure water cleaners (240MPa maximum pressure (including powerful vacuum trucks)	3.7 service days
Street drain cleaners (Capacity 5.1 m^3)	3.5 service days
Engine-generators (Rated 3 kvA, Low-noise type)	2.9 service days
Air compressor (Portable, Exhaust gas suppression type (Primary side) 3.5-3.7 m^3/min)	4.7 service days
Sprinkler trucks (Tank capacity 3,800 L)	4.3 service days
Light oil	1,207.2 L
Gasoline	9.5 L
Large sandbags	-

<table>
<tr><td colspan="2">Workforce needed</td><td>(per 1,300 m²)
<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>2.8 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>5.8 worker-days</td></tr><tr><td>Decontamination workers</td><td>4.8 worker-days</td></tr><tr><td>Drivers (special decontamination)</td><td>2.7 worker-days</td></tr><tr><td>Drivers (ordinary decontamination)</td><td>5.4 worker-days</td></tr></table></td></tr>
<tr><td rowspan="5">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Paved surfaces shall not be cleaned when frozen or snow covered.
● Superhigh pressure water cleaners may be not appropriate for scraping near curbs. Handy-type/edge-scraping type cleaners or high-pressure water cleaners can be used instead (costs of handy-type cleaners shall be reviewed). When non-water-recovery-type cleaners are used, the work shall be done under covers to prevent water dispersion and the cleaning water shall be collected from street drains.
● Radiation dose after decontamination shall be measured after the road surfaces are dried.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Rainwear, safety glasses, dust masks, hand gloves, etc. shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>● For the work on roads, barricades and traffic controllers shall be arranged.</td></tr>
<tr><td>Measures to prevent secondary wastes</td><td>● Scrapings (sludge) collected by coagulating sedimentation shall be thoroughly dehydrated and packed in large sandbags.</td></tr>
<tr><td>Others</td><td>–</td></tr>
</table>

6） Cleaning by road sweepers

Locations to be decontaminated	"6.1.2 Roads/sidewalks" of "6.1 Paved roads" of "6. Roads"
Decontamination methods	Cleaning by road sweepers

Outline	Paved roads/sidewalks shall be cleaned by road sweepers
Decontamination processes	● Paved roads/sidewalks shall be cleaned by road sweepers in preparation for the work by decontamination workers or for maintenance. ● Trash collected shall be packed in flexible containers.
Tools, equipment for decontamination work	(per 1 km) <table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Shovels, brooms, brushes, etc.</td><td>-</td></tr><tr><td>Road sweepers (Brush-type, Hopper capacity 3.1m³, 4-wheeled)</td><td>*3 (service hours)</td></tr><tr><td>Light oil</td><td>12 x *3 (L)</td></tr></table>Note) The estimate shall be changed, if sprinkler trucks are needed.
Workforce needed	(per 1 km) <table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>*1 (worker-hours)</td></tr><tr><td>Decontamination workers</td><td>*2 (worker-hours)</td></tr><tr><td>Drivers (ordinary decontamination)</td><td>*3 x 0.14 (worker-hours)</td></tr><tr><td>Assistants to decontamination workers</td><td>*3 x 0.13 (worker-hours)</td></tr></table>*1: 0.8×T1/T×1/L *2: 1.2×T1/T×1/L *3: T1/L T1=L/V1＋ℓ/V2 T1= Time required for work (h) L= Cleaning distance (km) V1= Cleaning speed (km/h)= 6.0 km/h (time for carrying away trash included) ℓ= Distance of journey (km) =ℓ1＋ℓ2＋ℓ3＋ℓ4 ℓ1= Distance between the workplace and surplus soil repository (km) ℓ2= Distance between the workplace and water

		supply point (km) ℓ3= Distance between the workplace to the next workplace (km) (assuming no need to clean in the section and the section is longer than ℓ4= Distance between the workplace and the base (km) In calculating the distance of journey (ℓ) above, following factors shall be considered. Δ L= Cleaning distance per hopper of street sweepers (km) = hopper capacity x hopper coefficient / amount of trash =(3.10×0.61)/0.1=18.91(km) V2= Driving speed (km/h) =30.0 km/h T= Road sweeper operation time per day =7.6 h/day
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● Paved surfaces shall not be cleaned when frozen or snow covered. ● Packing work of the contaminated materials removed and collected into flexible containers shall be done under covers to prevent dust from dispersion.
	Radiation exposure protection of workers	● Safety glasses, dust masks, rubber gloves, etc. shall be worn when working outdoors.
	General labor safety of workers	● Barricades and traffic controllers shall be arranged, as the work is done on the roads.
	Measures to prevent secondary wastes	–
	Others	–

(3) Weeds/lawns

1) Weeding, lawn mowing

Locations to be decontaminated	"1.4.1. Unpaved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like." "2.4.2. Weeds/lawns" of "2.4. Grounds and the like" at "2. Schools" "3.4.2. Weeds/lawns" of "3.4. Grounds and the like" in "3. Parks (small)" "4.4.2.Paved surfaces" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.2. Weeds/lawns" of "5.4. Grounds and the like" of "5. Large facilities" "6.6.2. Weeds" of "6.6. Roadside trees" of "6. Roads"
Decontamination methods	Weeding, lawn mowing

Outline	Weeds/lawns of residences, schools, parks, large facilities, and roadside trees, etc. shall be mowed in the following procedures (i) Weeding and mowing by mowers and the like ((ii) Collecting/transferring mowed weeds/grass) (iii) Packing of mowed weeds/grass
Decontamination processes	● Prior to removing sediment and surface soil, weeds that may hinder the work shall be removed or weeded by shoulder-type mowers or by hand. ● Packing of weeds/grass removed in large sandbags
Tools, equipment and the like for decontamination work	■When working on unpaved surfaces of gardens and the like of residences and the like (1.4.1) and grounds and the like of parks (small) (3.4.2), (per 1,300 m^2) (see table A below) ■ When working on grounds and the like, of schools, parks (large) and large facilities, etc. (2.4.2, 4.4.2, 5.4.2), (per 1,300 m^2) (see table B below)

Tools, equipment to use	Quantity
Mowers (shoulder-type, cutter edge 255mm)	18.9 service days
Gasoline	46.2 L
Large sandbags	-

Tools, equipment to use	Quantity
Dump trucks (load capacity 2t) (2t)	0.1 service days
Mowers (shoulder-type, cutter edge 255mm)	19.0 service days
Light oil	2.6 L

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<table>
<tr><td>Gasoline</td><td>46.2 L</td></tr>
<tr><td>Large sandbags</td><td>-</td></tr>
</table>
■When weeding roadside trees (6.6.2),
(per 1,300 m^2)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Mowers (shoulder-type, cutter edge 255mm)</td><td>6.0 service days</td></tr>
<tr><td>Light oil</td><td>3.8 L</td></tr>
<tr><td>Gasoline</td><td>14.5 L</td></tr>
<tr><td>Large sandbags</td><td>-</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Workforce needed</td><td>
■When working on unpaved surfaces of gardens and the like of residences and the like (1.4.1) and grounds and the like of parks (small) (3.4.2),
(per 1,300 m^2)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>1.8 worker-days</td></tr>
<tr><td>Specialized decontamination workers</td><td>10.2 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>1.5 worker-days</td></tr>
</table>
■When working on grounds and the like, of schools, parks (large) and large facilities, etc. (2.4.2, 4.4.2, 5.4.2),
(per 1,300 m^2)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>1.8 worker-days</td></tr>
<tr><td>Specialized decontamination workers</td><td>10.2 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>1.5 worker-days</td></tr>
<tr><td>Drivers (ordinary decontamination)</td><td>0.1 worker-days</td></tr>
</table>
■When working on roadside trees (6.6.2),
(per 1,300 m^2)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>1.3 worker-days</td></tr>
<tr><td>Specialized decontamination workers</td><td>3.2 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>5.5 worker-days</td></tr>
<tr><td>Drivers (special decontamination)</td><td>0.1 worker-days</td></tr>
</table>
</td></tr>
<tr><td>Idea development, lessons,</td><td>Prerequisites and constraints regarding objects and locations</td><td>● Decontamination work shall be halted when the weeds/lawns to be decontaminated are frozen or snow covered.</td></tr>
</table>

points to keep in mind, etc.	to be decontaminated	
	Radiation exposure protection of workers	● Safety glasses, masks, gloves, etc. shall be worn.
	General labor safety of workers	● For the work on road shoulders, barricades and traffic controllers shall be arranged. ● Mowers are simple machines, but it is easy for operators to be hurt. Measures shall be taken to prevent minor collisions with machines. <Major safety measures> ・ Availability of protective covers shall be checked. ・ Proper mounting of protective covers shall be checked. ・ Knife-proof gloves shall be worn. ・ A no-access area shall be set around the weed cutter (5 m). ・ Distance shall be reserved between weed cutters (15 m).
	Measures to prevent secondary wastes	● Cut weeds/grass shall be collected quickly in order to prevent scattering by wind and rain.
	Others	–

2）Deep mowing of lawns

Locations to be decontaminated	"1.4.1. Unpaved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like." "2.4.2. Weeds/lawns" of "2.4. Grounds and the like" at "2. Schools" "3.4.2. Weeds/lawns" of "3.4. Grounds and the like" in "3. Parks (small)" "4.4.2.Paved surfaces" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.2. Weeds/lawns" of "5.4. Grounds and the like" of "5. Large facilities"
Decontamination methods	Sod cutting

Outline	Weeds and lawns of unpaved surfaces of gardens and the like of residences and the like, and grounds of schools, parks, large facilities shall be removed by sod cutting in the following procedures (i) Lifting of lawns by sod cutters and the like ((ii) Collecting mowed weeds/grass, roots and soil (iii) Packing of removed materials
Decontamination processes	■ When working on weeds/lawns of unpaved surfaces of gardens and the like of residences and the like (1.4.1) and grounds and the like of parks (small) (3.4.2), ● Lawns shall be removed (reproducible shallow scraping of about 3 cm depth) using manually-guided sod cutters and the like after mowing. Root mat layers shall be preserved. ● Removed materials shall be packed in large sandbags. ● Bumps shall be covered with soil, and soil of 3 – 6 mm depth shall be scattered over them. ■When working on weeds/lawns of grounds and the like of schools, parks (large) and large facilities and the like (2.4.2, 4.4.2, 5.4.2), ● Large sod cutters, where possible, shall cut deeply (reproducible shallow scraping of about 3 cm depth). ● Where large sod cutters cannot gain access, manually-guided sod cutters and the like shall cut deeply (about 3 cm). ● Root mat layers shall be preserved. ● Removed materials shall be packed in large sandbags. ● Bumps shall be covered with soil, and soil of 3 – 6mm depth shall be scattered over them.

<table>
<tr><td>Tools, equipment and the like for decontamination work</td><td>

■ When working on weeds/lawns of unpaved surfaces of gardens and the like of residences and the like (1.4.1), and grounds and the like of parks (small) (3.4.2),

(per 1,300 m^2)

Tools, equipment to use	Quantity
Manually-guided sod cutters (cutting path 55 – 65 cm)	18.8 service days
Gasoline	63.0 L
Fresh soil for scattering over lawns	6.5 m^3
Large sandbags	-

■ When working on weeds/lawns of grounds and the like of schools, parks (large) and large facilities, etc. (2.4.2, 4.4.2, 5.4.2),

(per 1,300 m^2)

Tools, equipment to use	Quantity
Backhoes (Excavators) (Crawler type, Exhaust gas suppression type (secondary), Standard bucket capacity 0.28 m^3 when heaped (0.2 m^3 when flatly filled))	2.1 service days
Dump trucks (load capacity 2 t)	0.7 service day
Manually-guided sod cutters (cutting path 55 – 65 cm)	1.1 service days
Light oil	73.5 L
Gasoline	3.7 L
Fresh soil for scattering over lawns	6.5 m^3
Large sandbags	-

</td></tr>
<tr><td>Workforce needed</td><td>

■ When working on weeds/lawns of unpaved surfaces of gardens and the like of residences and the like (1.4.1), and grounds and the like of parks (small) (3.4.2),

(per 1,300 m^2)

Workforce needed	Quantity
Operation leaders	3.8 worker-days
Specialized decontamination workers	10.0 worker-days
Decontamination workers	15.0 worker-days

■ When working on weeds/lawns of grounds and the like of schools, parks (large) and large facilities, etc. (2.4.2, 4.4.2, 5.4.2),

</td></tr>
</table>

<table>
<tr><td colspan="2"></td><td>(per 1,300 m^2)
<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>0.6 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>0.6 worker-days</td></tr><tr><td>Decontamination workers</td><td>1.3 worker-days</td></tr><tr><td>Drivers (special decontamination)</td><td>1.3 worker-days</td></tr><tr><td>Drivers (ordinary decontamination)</td><td>0.6 worker-days</td></tr></table></td></tr>
<tr><td rowspan="5">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Decontamination work shall be halted when the weeds/lawns to be decontaminated are frozen or snow covered.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Safety glasses, masks and gloves shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>(When mowers, sod cutters and heavy machinery are used,)
● Setting of color cones or cone bars is recommended to designate working areas in order to prevent minor accidents by worker-machine collisions or being caught in a machine (Driver is in charge). (When mowers are used,)
● Mowers are simple machines, but it is easy for operators to be hurt. Measures shall be taken to prevent accidents due to minor collisions.
<Major safety measures>
・ Availability of protective covers shall be checked
・ Proper mounting of protective covers shall be checked.
・ Knife-proof gloves shall be worn.
・ A no-access area shall be set around the weed cutter (5 m).
・ Distance shall be reserved between weed cutters (15 m).</td></tr>
<tr><td>Measures to prevent secondary wastes</td><td>−</td></tr>
<tr><td>Others</td><td>−</td></tr>
</table>

(4) Gravel, crushed stones

1) Removal of gravel, crushed stones

Locations to be decontaminated	"1.4.1. Unpaved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like." "2.4.3. Gravel, crushed stone" of "2.4. Grounds and the like" at "2. Schools" "3.4.3 Gravel, crushed stone" of "3.4. Grounds and the like" in "3. Parks (small)" "4.4.3. Gravel, crushed stone" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.3. Gravel, crushed stone" of "5.4. Grounds and the like" of "5. Large facilities" "6.2.2. Road surfaces (roads of gravel, crushed stone)" of "6.2. Unpaved roads" of "6. Roads"
Decontamination methods	Removal of gravel, crushed stone

Outline	Gravel, and crushed stone of unpaved surfaces of gardens and the like of residences and the like, of grounds of schools, parks, large facilities, and unpaved road surfaces (roads of gravel or crushed stones) shall be removed in the following procedures (i) Removing gravel and crushed stone (ii) Packing removed gravel and crushed stone
Decontamination processes	■When working on gravel and crushed stone of unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.3), ● Gravel and crushed stone shall be uniformly removed (to about 5 cm depth) with shovels and the like, and packed in large sandbags. ● When the existing gravel or crushed stone is less than 5 cm deep, the top layer about 5 cm deep and including the soil underneath shall be uniformly removed and be packed in large sandbags. ■When working on gravel and crushed stone from grounds and the like of schools, parks (large), large facilities, etc. (2.4.3, 4.4.3, 5.4.3), ● Gravel and crushed stone shall be uniformly removed (to about 5 cm depth) with backhoes and the like, and packed in large sandbags. ● When the existing gravel or crushed stone is less than 5 cm deep, the top layer about 5 cm deep and including the soil underneath shall be uniformly removed and be packed in large

<table>
<tr><td></td><td>sandbags.

■When working on gravel and crushed stone of unpaved road surfaces (roads of gravel and crushed stone) (6.2.2),
● The top surface layer shall be scraped away in a uniform thicknesses (about 5 cm from the top) by backhoes and the like, and packed in large sandbags.</td></tr>
<tr><td>Tools, equipment and the like for decontamination work</td><td>■When working on gravel and crushed stone of unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.3),
(per 1,300 m²)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Shovels and the like</td><td>-</td></tr>
<tr><td>Large sandbags</td><td>-</td></tr>
</table>

■When working on gravel and crushed stone from grounds and the like of schools, parks (large), large facilities, etc. (2.4.3, 4.4.3, 5.4.3),
(per 1,000 m²)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Shovels and the like</td><td>-</td></tr>
<tr><td>Backhoes (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.45 m³ when heaped (0.35 m³ when flatly filled))</td><td>1.4 service days</td></tr>
<tr><td>Backhoes (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.28 m³ when heaped (0.2 m³ when flatly filled))</td><td>3.9 service days</td></tr>
<tr><td>Backhoes (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.13 m³ when heaped (0.10 m³ when flatly filled))</td><td>2.8 service days</td></tr>
<tr><td>Light oil</td><td>360.1 L</td></tr>
<tr><td>Large sandbags</td><td>-</td></tr>
</table>

■When working on gravel and crushed stone of unpaved road surfaces (roads of gravel and crushed stones) (6.2.2),
(per 1,300 m²)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Shovels and the like</td><td>-</td></tr>
<tr><td>Backhoes (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity</td><td>11.2 service days</td></tr>
</table></td></tr>
</table>

<table>
<tr><td></td><td><table>
<tr><td>0.28m³ when heaped (0.20 m³ when flatly filled))</td><td></td></tr>
<tr><td>Vibratory rollers (Combined type, 3.0 – 4.0 t weight)</td><td>5.6 service days</td></tr>
<tr><td>Light oil</td><td>565.2 L</td></tr>
<tr><td>Large sandbags</td><td>-</td></tr>
</table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>■When working on gravel and crushed stone of unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.3),
(per 1,300 m²)<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>7.7 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>51.4 worker-days</td></tr>
</table>
■When working on gravel and crushed stone from grounds, and the like, of schools, parks (large), large facilities, etc. (2.4.3, 4.4.3, 5.4.3),
(per 1,000m²)<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>1.7 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>11.1 worker-days</td></tr>
<tr><td>Drivers (special decontamination)</td><td>8.1 worker-days</td></tr>
</table>
■When working on gravel and crushed stone of unpaved road surfaces (roads of gravel and crushed stones) (6.2.2),
(per 1,300 m²)<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>2.7 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>17.9 worker-days</td></tr>
<tr><td>Drivers (special decontamination)</td><td>16.8 worker-days</td></tr>
</table></td></tr>
<tr><td rowspan="2">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Heavy machinery (small backhoes and the like) are preferable to the extent possible for better construction efficiency.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Masks, gloves and the like shall be worn when working with shovels and the like.</td></tr>
</table>

	General labor safety of workers	• Setting of color cones or cone bars is recommended to designate working areas in order to prevent minor accidents by worker-machine collisions or being caught in a machine (Driver is in charge). • For the work on roads, barricades and traffic controllers shall be arranged.
	Measures to prevent secondary wastes	• Attention is needed to prevent excessive digging by machinery. Digging depth indicators shall be set for construction.
	Others	–

(5) Soil

1) Surface soil removal from rainwater gutter drains, under-eaves, etc.

Locations to be decontaminated	■Surface soil removal from rainwater gutter drains, under-eaves, etc. "2.4.4. Soil" of "2.4. Grounds and the like" at "2. Schools" "4.4.4. Soil" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.4. Soil" of "5.4. Grounds and the like" of "5. Large facilities" ■Surface soil removal from the bases of trees such as roadside trees and the like "1.4.1. Unpaved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like" "2.4.5. Planted vegetation" of "2.4. Grounds and the like" at "2. Schools" "3.4.5 Planted vegetation" of "3.4. Grounds and the like" in "3. Parks (small)" "4.4.5. Planted vegetation" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.5. Planted vegetation" of "5.4. Grounds and the like" of "5. Large facilities" "6.6.3. Roadside trees" of "6.6. Roadside trees" of "6. Roads"
Decontamination methods	Soil sediment removal from rainwater gutter drains, under-eaves, etc. Surface soil removal near the bases of trees and roadside trees

Outline	Soil sediment of rainwater gutter drains, under-eaves, etc. of schools, parks, large facilities, etc. shall be removed in the following procedures. Similarly, surface soil of gardens and the like of residences and the like, and grounds of schools, parks, large facilities, etc., and soil near the bases of planted vegetation on the roads, trees, roadside trees, etc. shall be removed in the following procedures, (i) Removing surface soil (ii) Packing removed soil
Decontamination processes	● Fallen leaves and soil sediment shall be collected using a shovel or rake, etc. and packed in large sandbags.
Tools, equipment and the like for decontamination work	See table below
Workforce needed	See table below

Tools, equipment and the like for decontamination work:

Tools, equipment to use	Quantity
Shovels, rakes, etc.	-
Large sandbags	-

Workforce needed:

(per 1,300 m^2)

Workforce needed	Quantity
Operation leaders	2.0 worker-days
Decontamination workers	13.3 worker-days

Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● The work site could be a high dose level place (hereafter hot spot) depending on the rainfall conditions. The work flow to designate a hot spot and monitoring threshold criteria shall be prescribed in advance in consultation with the supervisory personnel by referring to the radiation levels around the hot spot.
	Radiation exposure protection of workers	● Masks and gloves shall be worn under dust handling conditions ● Protective gear shall be considered and a half-face mask and hand gloves (cotton, rubber) shall be worn if the radiocesium concentration is high in the soil to handle, and if the work corresponds to the work under high dust concentrations as designated in relevant guidelines of the Ministry of Health, Labour and Welfare(MHLW). ● If the work site is a hot spot, color cones and the like shall be arranged, as appropriate, for indicating the hot spot in order to facilitate reducing the long-term exposure of workers.
	General labor safety of workers	● Safety measures shall be taken for the work with heavy machinery (proper arrangement for preventing minor collisions of adjacently working heavy machinery, and adequate instructions and supervision, as well as thorough control for preventing access to the machinery)
	Measures to prevent secondary wastes	–
	Others	–

2）Scraping of surface soil

Locations to be decontaminated	"1.4.1. Unpaved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like" "2.4.4. Soil" of "2.4. Grounds and the like" at "2. Schools" "3.4.4. Soil" of "3.4. Grounds and the like" in "3. Parks (small)" "4.4.4. Soil" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.4. Soil" of "5.4. Grounds and the like" of "5. Large facilities" "6.2.1. Road surfaces (soil)" of "6.2. Unpaved roads" of "6. Roads"
Decontamination methods	Scraping of surface soil

Outline	Soil of unpaved gardens and the like of residences and the like, of grounds and the like of schools, parks, large facilities, etc. and the unpaved road surface (soil) shall be scraped off in the following procedures, (i) Scraping off surface soil (ii) Packing scraped soil
Decontamination processes	■ When working on the unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.4), ● The garden topsoil shall be uniformly scraped away (about 5 cm deep) by using bamboo rakes or similar instruments, and packed in large sandbags. ● Work breakdown shall be standardized and workers shall be instructed prior to the work in order to avoid non-uniformity of scraping thicknesses among workers. ■When working on the soil of grounds and the like of schools, parks (large), large facilities, etc. (2.4.4, 4.4.4, 5.4.4), ● The surface soil shall be uniformly scraped (about 5 cm deep) with backhoes and the like, and packed in large sandbags. ■ When working on the soil of unpaved road surfaces (6.2.1), ● The surface soil shall be uniformly scraped (about 5 cm deep) with backhoes and the like, and packed in large sandbags.
Tools, equipment and the like for decontamination work	■ When working on the unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.4),

	<table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Bamboo rakes and the like</td><td>-</td></tr><tr><td>Large sandbags</td><td>-</td></tr></table> ■When working on the soil of grounds and the like of schools, parks (large), large facilities, etc. (2.4.4, 4.4.4, 5.4.4), (per 1,000 m^2) <table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Shovels and the like</td><td>-</td></tr><tr><td>Backhoe (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.45 m^3 when heaped (0.35 m^3 when flatly filled))</td><td>2.7 service days</td></tr><tr><td>Backhoe (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.28 m^3 when heaped (0.20 m^3 when flatly filled))</td><td>2.0 service days</td></tr><tr><td>Backhoes (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.13 m^3 when heaped (0.10 m^3 when flatly filled))</td><td>0.2 service days</td></tr><tr><td>Light oil</td><td>360.1 L</td></tr><tr><td>Large sandbags</td><td>-</td></tr></table> ■When working on the soil of unpaved road surfaces (6.2.1), (per 1,300 m^2) <table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Shovels and the like</td><td>-</td></tr><tr><td>Backhoes (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.28 m^3 when heaped (0.2 m^3 when flatly filled))</td><td>8.0 service days</td></tr><tr><td>Light oil</td><td>362.9 L</td></tr><tr><td>Large sandbags</td><td>-</td></tr></table>
Workforce needed	■When working on the unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.4), (per 1,300 m^2) <table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>5.0 worker-days</td></tr><tr><td>Decontamination workers</td><td>33.4 worker-days</td></tr></table> ■When working on the soil of grounds and the

like of schools, parks (large), large facilities, etc. (2.4.4, 4.4.4, 5.4.4),

(per 1,000 m^2)

Workforce needed	Quantity
Operation leaders	1.0 worker-days
Decontamination workers	6.5 worker-days
Drivers (special decontamination)	4.9 worker-days

■ When working on the soil of unpaved road surfaces (soil) (6.2.1),

(per 1,300 m^2)

Workforce needed	Quantity
Operation leaders	1.8 worker-days
Decontamination workers	11.8 worker-days
Drivers (special decontamination)	8.0 worker-days

Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● The scraping thickness shall be set before the work. During the work, the scraping thickness shall be properly confirmed for sure dose reduction.
	Radiation exposure protection of workers	● Masks and hand gloves shall be worn.
	General labor safety of workers	● Safety measures shall be taken for the work with heavy machinery (proper arrangement for preventing minor collisions of adjacently working heavy machinery, and adequate instructions and supervision, as well as thorough control for preventing access to the machinery)
	Measures to prevent secondary wastes	–
	Others	–

3） Soil surface covering

Locations to be decontaminated	"1.4.1. Unpaved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like" "2.4.4. Soil" of "2.4. Grounds and the like" at "2. Schools" "3.4.4. Soil" of "3.4. Grounds and the like" in "3. Parks (small)" "4.4.4. Soil" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.4. Soil" of "5.4. Grounds and the like" of "5. Large facilities" "6.2.1. Road surfaces (soil)" of "6.2. Unpaved roads" of "6. Roads"
Decontamination methods	Soil surface covering

Outline	Soil of unpaved gardens and the like of residences and the like, of grounds and the like of schools, parks, large facilities, etc. and the unpaved road surface (soil) shall be covered in the following procedures, (i) Covering of surface soil uniformly with fresh uncontaminated soil, ((ii) Short distance transfer of fresh soil to small places for spreading) (iii) Compacting
Decontamination processes	■ When working on the unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.4), ● The surface, if its topsoil is scraped away, shall be covered by fresh soil of similar quality as before to a similar height. ● The new topsoil shall be spread, leveled and compacted back to the original height and similar porosity. ■When working on the grounds and the like of schools, parks (large), large facilities, etc. (2.4.4, 4.4.4, 5.4.4), ● The surface, if its topsoil is scraped away, shall be covered by fresh soil of similar quality as before to a similar height by using backhoes and the like. ● The new topsoil shall be spread, leveled and compacted back to the original height and similar porosities. ■When working on the unpaved road surfaces (soil) (6.2.1), ● The surface, if its topsoil is scraped away, shall be covered by fresh soil of similar quality as before to a similar height using backhoes and the like.

	● The new topsoil shall be spread, leveled and compacted back to the original maximum height and similar porosity.
Tools, equipment and the like for decontamination work	■When working on the unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.4),

(per 1,300 m²)

Tools, equipment to use	Quantity
Shovels and the like.	-
Vibratory rollers (hand guide type, 0.8 – 1.1 t weight)	15.8 service days
Light oil	56 L
Fresh soil for covering	72.2 m^3

■When working on the grounds and the like of schools, parks (large), large facilities, etc. (2.4.4, 4.4.4, 5.4.4),

(per 1,000 m²)

Tools, equipment to use	Quantity
Shovels and the like	-
Backhoes (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.28 m^3 when heaped (0.20 m^3 when flatly filled))	1.1 service days
Vibratory roller (Exhaust gas suppression type (primary), Combined type, 3 – 4 t)	1.5 service days
Vibratory rollers (Exhaust gas suppression type, manually-guided type, 0.5 – 0.6 t)	0.4 service days
Dump trucks (load capacity 2 t)	1.8 service days
Light oil	106.6 L
Fresh soil for covering	55.5 m^3

■When working on the unpaved road surfaces (soil) (6.2.1),

(per 1,300 m²)

Tools, equipment to use	Quantity
Shovels and the like	-
Backhoes (Crawler type, Exhaust gas suppression type (secondary), 0.28 m^3 when heaped (0.20 m^3 when flat))	19.0 service hours
Vibratory rollers (Exhaust gas suppression type (primary), Combined type, 3 – 4 t)	2.0 rollers per day

<table>
<tr><td colspan="2"></td><td><table><tr><td>Light oil</td><td>156.0 L</td></tr><tr><td>Fresh soil for covering</td><td>72.2 m³</td></tr></table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>■ When working on the unpaved surfaces of gardens and the like, of residences and the like (1.4.1) and of grounds and the like of parks (3.4.4),
(per 1,300m²)
<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>3.3 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>11.5 worker-days</td></tr><tr><td>Decontamination workers</td><td>10.7 worker-days</td></tr></table>
■When working on the grounds and the like of schools, parks (large), large facilities, etc. (2.4.4, 4.4.4, 5.4.4),
(per 1,000 m²)
<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>0.7 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>0.4 worker-days</td></tr><tr><td>Decontamination workers</td><td>4.7 worker-days</td></tr><tr><td>Drivers (special decontamination)</td><td>2.6 worker-days</td></tr><tr><td>Drivers (ordinary decontamination)</td><td>1.5 worker-days</td></tr></table>
■When working on the unpaved road surfaces (soil) (6.2.1),
(per 1,300 m²)
<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>3.5 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>6.9 worker-days</td></tr><tr><td>Decontamination workers</td><td>1.4 worker-days</td></tr><tr><td>Drivers (special decontamination)</td><td>3.0 worker-days</td></tr></table></td></tr>
<tr><td rowspan="2">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● It was hard to secure similar soil/stones as the original ones for the gardens of private residences. Occasionally, it was difficult to obtain their consent to the materials even when similar ones were offered.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● The work is often done combined with scraping work. Protective gear such as masks shall be worn even though the dose decreases</td></tr>
</table>

		once fresh soil is spread.
	General labor safety of workers	● Safety measures shall be taken for the work with heavy machinery (proper arrangement for preventing minor collisions of adjacently working heavy machinery, and adequate instructions and supervision, as well as thorough control for preventing access to the machinery)
	Measures to prevent secondary wastes	–
	Others	–

4）Deep plowing

Locations to be decontaminated	"1.4.1. Unpaved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like" "2.4.4. Soil" of "2.4. Grounds and the like" at "2. Schools" "3.4.4. Soil" of "3.4. Grounds and the like" in "3. Parks (small)" "4.4.4. Soil" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.4. Soil" of "5.4. Grounds and the like" of "5. Large facilities" "6.2.1. Road surfaces (soil)" of "6.2. Unpaved roads" of "6. Roads"
Decontamination methods	Deep plowing

Outline	Soil of unpaved gardens and the like of residences and the like, of grounds and the like of schools, parks, large facilities, etc. and the unpaved road surface (soil) shall be plowed deeply in the following procedures, (i) Excavating surface soil for temporary storage, (ii) Excavating sub-surface soil for temporary storage, (iii) Spreading and compacting of surface soil (in the sub-surface layer) (iv) Spreading and compacting of sub-surface soil (in the surface layer) (v) Leveling the top surface
Decontamination processes	■When working on the unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.4), ● The surface soil to about 10 cm depth shall be uniformly scraped away by hand using shovels and the like and be placed temporarily on plastic sheets and the like. ● The sub-surface soil to about 20 cm depth shall be uniformly scraped away and be placed temporarily apart from the surface soil storage. ● The surface soil shall be spread in the sub-surface layer using shovels. The sub-surface soil shall be spread over it, leveled and compacted to the original level with similar porosity. ■When working on the grounds and the like of schools, parks (large), large facilities, etc. (2.4.4, 4.4.4, 5.4.4), and the unpaved road surfaces (soil) (6.2.1), ● The surface soil to about 10 cm depth shall be uniformly scraped away by using backhoes and be placed temporarily on plastic sheets and the like. ● The sub-surface soil to about 20 cm depth shall be uniformly scraped away and be placed

- temporarily apart from the surface soil storage.
- The surface soil shall be spread with shovels by hand or using backhoes. The sub-surface soil shall be spread over it, leveled and compacted to the original level with similar porosity

Tools, equipment and the like for decontamination work

■When working on the unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.4),

Tools, equipment to use	Quantity
Shovels and the like	-
Compactors (Dumpers)	-
Plastic sheets	-

■When working on the grounds and the like of schools, parks (large), large facilities, etc. (2.4.4, 4.4.4, 5.4.4), and the unpaved road surfaces (soil) (6.2.1),

(per 1,300 m^2)

Tools, equipment to use	Quantity
Shovels and the like	-
Backhoes (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.28 m^3 when heaped (0.20 m^3 when flat))	7.9 service days
Backhoes (Crawler type, Exhaust gas suppression type (secondary), Bucket capacity 0.45 m^3 when heaped (0.35 m^3 when flat))	6.1 service days
Vibratory rollers (Exhaust gas suppression type (primary), combined type, 3 – 4 t)	7.9 service days
Light oil	549.9 L
Plastic sheet	-

Workforce needed

■When working on the unpaved surfaces of gardens and the like of residences and the like (1.4.1), and of grounds and the like of parks (3.4.4),

(per 1,300 m^2)

Workforce needed	Quantity
Operation leaders	26.0 worker-days
Decontamination workers	173.0 worker-days

■When working on the grounds and the like of schools, parks (large), large facilities, etc. (2.4.4, 4.4.4, 5.4.4), and the unpaved road surfaces (soil) (6.2.1),

<table>
<tr><td colspan="2"></td><td>(per 1,300 m²)<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>1.3 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>6.2 worker-days</td></tr><tr><td>Decontamination workers</td><td>8.5 worker-days</td></tr></table></td></tr>
<tr><td rowspan="5">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● In many cases, especially in residential areas, this method is often not accepted because the contaminated soil is not removed.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Dust masks and rubber gloves shall be worn when working by hands using shovels and the like.
● Contaminated surface soil collected and piled up forms temporary hot spots. Early backfill is desirable before the radiation dose becomes high.</td></tr>
<tr><td>General labor safety of workers</td><td>● Safety measures shall be taken for the work with heavy machinery (proper arrangement for preventing minor collisions of adjacently working heavy machinery, and adequate instructions and supervision, as well as thorough control for preventing access to the machinery)</td></tr>
<tr><td>Measures to prevent secondary wastes</td><td>–</td></tr>
<tr><td>Others</td><td>–</td></tr>
</table>

(6) Garden trees, planted vegetation, roadside trees

1) Surface soil removal from bases of trees and the like

The same as the soil sediment removal from rainwater gutter drains, under-eaves, etc. in the residential areas, schools, parks, large facilities, roads, etc. explained in (5) 1).

2) Delimbing of garden trees, planted vegetation and roadside trees

Locations to be decontaminated	■Delimbing of garden trees “1.4.1. Unpaved surfaces” of “1.4. Gardens and the like” in “1. Residential areas and the like” ■Delimbing of planted vegetation “2.4.5. Planted vegetation” of “2.4. Grounds and the like” at “2. Schools” “3.4.5. Planted vegetation” of “3.4. Grounds and the like” in “3. Parks (small)” “4.4.5. Planted vegetation” of “4.4. Grounds and the like” in “4. Parks (large)” “5.4.5. Soil Planted vegetation” of “5.4. Grounds and the like” of “5. Large facilities” ■Delimbing of roadside trees “6.6.3. Roadside trees” of “6.6. Roadside trees” of “6. Roads”
Decontamination methods	Delimbing of garden trees, planted vegetation and roadside trees

Outline	Garden trees of residences and the like, planted vegetation of the grounds of schools, parks, large facilities, etc., and roadside trees shall be delimbed in the following procedures. (i) Delimbing of garden trees, hedges, planted vegetation ((ii) Collecting fallen leaves and the like and small amount transfer of collected materials) (iii) Packing collected materials
Decontamination processes	● Garden trees, hedges, planted vegetation and roadside trees shall be delimbed or pruned by using pruners and branch cutters, to an extent that does not cause significant harm to their growth according to the tree species and their delimbing period. ● Branches trimmed off shall be packed in large sandbags. Too long branches for large sandbags shall be chopped into short lengths for packing
Tools, equipment and the like for decontamination work	■When working on garden trees of unpaved surfaces of gardens and the like of residences and the like (1.4.1), planted vegetation of the grounds

and the like of schools, parks, large facilities, etc. ‘2.4.5, 3.4.5, 4.4.5, 5.4.5),

Tools, equipment to use	Quantity
Rakes and the like	-
Chain saws (Edge length 350 mm, exhaust 34 cc))	6.5 service days
Gasoline	7.0 L
Large sandbags	-

■When working on roadside trees (6.6.3),

(per 1,300 m²)

Tools, equipment to use	Quantity
Bamboo rakes and the like	-
Aerial lift work vehicles (Lift-mounted truck, beam-type, work floor elevation 9.7 m)	11.2 service days
Chain saws (Edge length 350 mm, exhaust 34 cc))	20.0 service days
Crane trucks (Load capacity 4 t, Suspension weight 2.9 t)	3.3 service days
Light oil	259.9 L
Gasoline	21.6 L
Large sandbags	-

Workforce needed

■When working on garden trees of unpaved surfaces of gardens and the like of residences and the like (1.4.1), planted vegetation of the grounds and the like of schools, parks, large facilities, etc. ‘2.4.5, 3.4.5, 4.4.5, 5.4.5),

(per 1,300 m²)

Workforce needed	Quantity
Operation leaders	2.1 worker-days
Plant decontamination workers	11.5 worker-days

■When working on roadside trees (6.6.3),

(per 1,300m²)

Workforce needed	Quantity
Operation leaders	4.2 worker-days
Specialized decontamination workers	9.0 worker-days
Decontamination workers	8.0 worker-days
Drivers (special decontamination)	10.7 worker-days

Idea development, lessons,	Prerequisites and constraints regarding objects and locations	● Subject to the heights of garden trees, planted vegetation and roadside trees the delimbing work becomes the same as the

points to keep in mind, etc.	to be decontaminated	pruning work of coniferous trees (11.1.3.1). ● Some municipalities set rules to unify the pruning heights. Such cases shall be checked in advance, and preparatory consultation shall be carried out as needed.
	Radiation exposure protection of workers	● Safety glasses, dust masks, hand gloves, etc. shall be worn.
	General labor safety of workers	● Workers shall wear safety glasses, when delimbing and pruning, to prevent chips/dust from getting into their eyes. ● Work areas shall be clearly indicated and a no-access area shall be set. ● Pruning with chain saws shall be done in a standing and stable posture. ● When carrying a chain saw in the hands, the engine shall be switched off, braked, and carried using both hands. ● Allowable time for use shall be indicated on each chain saw on a sticky tape and the like (to prevent vibration hazard) ● For delimbing higher branches by using branch-cutters and the like, working positions shall be appropriately chosen to prevent the cut branches from hitting the workers.
	Measures to prevent secondary wastes	–
	Others	● Requests from some municipalities shall be considered to shake down twigs and leaves stuck on the branches around the pruning area.

3) Cutting of garden trees and planted vegetation

Locations to be decontaminated	■Cutting of garden trees "1.4.1. Unpaved surfaces" of "1.4. Gardens and the like" in "1. Residential areas and the like" ■Cutting of planted vegetation "2.4.5. Planted vegetation" of "2.4. Grounds and the like" at "2. Schools" "3.4.5. Planted vegetation" of "3.4. Grounds and the like" in "3. Parks (small)" "4.4.5. Planted vegetation" of "4.4. Grounds and the like" in "4. Parks (large)" "5.4.5. Soil Planted vegetation" of "5.4. Grounds and the like" of "5. Large facilities"
Decontamination methods	Cutting of garden trees and planted vegetation

Outline	Garden trees of residences and the like and planted vegetation of the grounds of schools, parks, large facilities, etc. shall be cut in the following procedures. (i) Cutting garden trees and hedges (ii) Pruning and cross-cutting (iii) Packing collected materials
Decontamination processes	● Garden trees, hedges and planted vegetation shall be cut using chain saws and the like. ● Branches pruned and the like shall be packed in large sandbags. Too long branches for large sandbags shall be chopped into short lengths for packing.
Tools, equipment and the like for decontamination work	(per 13 trees) (see table below) *Applicable when the diameter at the chest level exceeds 6 cm. *Rough terrain cranes, if needed, shall be selected which meet the codes for field conditions.
Workforce needed	(per 13 pieces) (see table below)

Tools, equipment and the like for decontamination work (per 13 trees)

Tools, equipment to use	Quantity
Chain saws (Edge length 350 mm, exhaust 34 cc)	2.5 service days
Gasoline	2.7 L
Large sandbags	-

Workforce needed (per 13 pieces)

Workforce needed	Quantity
Operation leaders	0.9 worker-days
Plant decontamination workers	1.0 worker-day

<table>
<tr><td colspan="2"></td><td><table><tr><td>Decontamination workers</td><td>4.9 worker-days</td></tr></table>*Applicable when the diameter at the chest level exceeds 6 cm.</td></tr>
<tr><td rowspan="5">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Trees to be cut shall be confirmed with stakeholders in presence and duly marked for preventing possible trouble.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Safety glasses, masks, rubber gloves, etc. shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>● Workers shall wear safety glasses, when delimbing and pruning, to prevent chips/dust from getting into their eyes.
● Work areas shall be clearly indicated and a no-access area shall be set.
● Commencement of the cutting work shall be signaled to nearby workers in the pre-arranged method.
● Chain saws shall be operated in a stable posture.
● When carrying a chain saw in the hands, the engine shall be switched off, braked and carried using both hands.
● Allowable time for use shall be indicated on each chain saw on a sticky tape and the like (to prevent vibration hazard).</td></tr>
<tr><td>Measures to prevent secondary wastes</td><td>–</td></tr>
<tr><td>Others</td><td>–</td></tr>
</table>

(7) Other objects to be decontaminated

1) Wiping, cleaning and scraping of playground equipment

Locations to be decontaminated	"2.5.1. Playground equipment and the like" of "2.5. Playground equipment and the like" at "2. Schools" "3.5.1. Playground equipment and the like" of "3.5. Playground equipment and the like" in "3. Parks (small)" "4.5.1. Playground equipment and the like" of "4.5. Playground equipment and the like" in "4. Parks (large)" "5.5.1. Playground equipment and the like" of "5.5. Playground equipment and the like" of "5. Large facilities"
Decontamination methods	Wiping, cleaning and scraping of playground equipment and the like

Outline	Playground equipment and the like of schools, parks, large facilities, etc. shall be wiped, cleaned or scraped.
Decontamination processes	● Surfaces of playground equipment shall be cleaned with water by using brushes, cleaning cloths and the like. Neutral detergents, vinegar (diluted acetic acid), etc. shall be used as needed. ● In wiping, cleaning cloths and the like moistened with water and the like (including neutral detergents, vinegar) shall be used with each face of the folded cloths used until repeated wiping gives hardly any further reduction in the surface contamination density.
Tools, equipment and the like for decontamination work	(see table below)
Workforce needed	(see table below)

Tools, equipment and the like for decontamination work:

Tools, equipment to use	Quantity
Cleaning cloths and the like	-
High-pressure water cleaners	-
Sand paper, grinders, etc.	-
Brushes, sand paper, electric tools, etc.	-
Large sandbags	-

Workforce needed:

(per piece of playground equipment)

Workforce needed	Quantity
Operation leaders	0.1 worker-days
Decontamination workers	0.4 worker-days

* Applicable to two-seat swings (2.0 m high, 3.0 m wide), one way slides (2.0 m high, 40 cm wide x 4.0 m long slide face), etc.

Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● A fresh wiping face of the cloth shall be used for each wiping step, in order to prevent contaminants being reattached to the equipment. ● Paper towels and the like shall be used for wiping of flat surfaces of painted equipment (horizontal bars, jungle gyms, etc.). Dry brushes shall be used on uneven surfaces such as monuments at schools and the like. ● Possibilities of paint stripping upon wiping and brushing of playground equipment at schools shall be discussed with the educational committee in advance.
	Radiation exposure protection of workers	● Paper towels used for wiping shall not be touched with the bare hands, because they may be contaminated with radiocesium. ● The air dose rate in the working area shall be clearly indicated and the workers notified. ● The dose rates in the decontamination working area shall be measured in advance and, if the dose rate is high, the area shall be clearly indicated by color cones, color cone bars, etc. ● Daily and accumulated exposure doses of individual workers shall be indicated in an easily understandable way and kept under control. ● Unnecessary access to large packed sandbags shall be restricted because of high dose rate risk. ● Protective equipment such as disposable masks, rubber gloves, etc. shall be disposed of at the pre-designated spots when the work is finished.
	General labor safety of workers	● Protective equipment (masks, gloves, etc.) shall be properly worn. ● Stability and safety of work floors shall be ensured for the work in high places such as 2 m high swings.
	Measures to prevent secondary wastes	● For volume reduction of secondary wastes, paper towels and other disposable items used in wiping work shall be pressed, or suction-compressed by vacuum cleaners into sealed storage bags.
	Others	● When leaving the working areas, contamination on body surfaces shall be checked as lower than 1,300 cpm by screening, which is stricter than the allowable limit of 13,000 cpm.

2）Removal of bottom sediment from street drains and the like of roads

Locations to be decontaminated	"6.4.1. Street drains and the like" of "6.4. Street drains and the like" of "6. Roads"
Decontamination methods	Removal of bottom sediment from street drains and the like of roads

<table>
<tr><td colspan="2">Outline</td><td>Bottom sediment of street drains and the like of roads shall be removed in the following procedures:
(i) High-pressure water cleaning of bottom sediment
(ii) Suctioning up sediment
(iii) Transfer of wastewater to a wastewater treatment facility</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>● High-pressure water of about 14 MPa from drainage pipe cleaners and the like shall be used for cleaning in about 20 L/m³. The wastewater shall be collected.
● Sediment removed shall be packed in large sandbags. The wastewater collected shall be transported to an on-site or nearby wastewater treatment facility.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td>(per 1,300 m)<table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Shovels, brooms, etc.</td><td>-</td></tr><tr><td>Drainage pipe cleaners (Floor-type, hopper capacity 10.3m³, air-flow 40m³/min)</td><td>4.0 service days</td></tr><tr><td>Drainage pipe cleaners (Floor-type, hopper capacity 3.1 m³, air-flow 40 m³/min)</td><td>1.2 service days</td></tr><tr><td>Drainage pipe cleaner (Tank capacity 2m³, pressure 14MPa)</td><td>5.3 service days</td></tr><tr><td>Light oil</td><td>457.6 L</td></tr><tr><td>Water</td><td>9.0 m³</td></tr></table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per 1,300 m)<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>4.1 worker-days</td></tr><tr><td>Decontamination workers</td><td>19.2 worker-days</td></tr><tr><td>Drivers (ordinary decontamination)</td><td>8.1 worker-days</td></tr></table></td></tr>
<tr><td>Idea development,</td><td>Prerequisites and constraints regarding</td><td>● Sediment easily removable such as fallen leaves, moss or mud shall be removed in</td></tr>
</table>

lessons, points to keep in mind, etc.	objects and locations to be decontaminated	advance by shovels and the like. ● When the concrete joint gaps of street drains are deep, a spatula or the like shall be used to remove the sediment from the joint gaps. ● The cleaning shall be done under covers to avoid water scattering when buildings stand closely next to each other. ● When cleaning covered street drains by using high-pressure water, the cleaner shall be equipped with a spray nozzle for high-pressure water that is inserted in the street drains of the roads in order to clean the bottom, sides and top (backside of the cover) of the covered drains. ● When a spray nozzle cannot be equipped on the high-pressure water cleaner for covered street drains, for instance when much sand has flowed from mountains and slopes into the street drains, the cover shall be removed temporarily and cleaning shall be done by hand. ● When removing sediment with hand by using shovels and the like from street drains without a cover, wheelbarrows shall be used for transferring sediment removed to a nearby spot for collection, as the road surface is smooth. ● Before commencing the high-pressure water cleaning of street drains, the wastewater discharge lines shall be checked, and small sandbags shall be lined up to dam the street drains downstream. The wastewater shall be collected by a street drain cleaner. Small sandbags containing zeolites shall be placed downstream to prepare for possible overflow incidents.
	Radiation exposure protection of workers	● The dose rates in the working area shall be indicated clearly and the workers notified. ● The dose rates in the decontamination working area shall be measured in advance and, if the dose rate is high, the area shall be clearly indicated by color cones, color cone bars, etc. ● Daily and accumulated exposure doses of individual workers shall be indicated in an easily understandable way and kept under control. ● Unnecessary access to large packed sandbags shall be restricted because of their high dose rate risk. ● Protective equipment such as disposable masks, rubber gloves, etc. shall be disposed of

		at the pre-designated spots when the work is finished.
	General labor safety of workers	● Protective equipment (masks, gloves, etc.) shall be properly worn. ● No one shall stand in the water jet zones at the time of high-pressure water cleaning. ● Attention shall be paid not to cut the fingers when cleaning street drains by hand using spatulas or the like.
	Measures to prevent secondary wastes	–
	Others	● When leaving the working area, contamination on body surfaces shall be checked as lower than 1,300 cpm by screening, which is stricter than the allowable limit of 13,000 cpm.

6.1.2. Slopes

1) Removal of weeds, fallen leaves and sediment on slopes

Locations to be decontaminated	"7.1.1. Weeds, fallen leaves, sediment" of "7.1. Slopes" of "7. Slopes"
Decontamination methods	Removal of weeds, fallen leaves and sediment on slopes

Outline		Weeds, fallen leaves and sediment on slopes shall be removed in the following procedures: (i) Branches and leaves, shrubs, weeds, etc. which can impede decontamination work shall be removed (weeding, cutting) with shoulder-type mowers, sickles, etc. (ii) Weeds, fallen leaves and sediment shall be removed. (iii) Transferring removed materials (iv) Packing removed materials
Decontamination processes		● Sediment such as fallen leaves, moss, mud, etc. shall be removed by rakes and other tools and packed in large sandbags.
Tools, equipment and the like for decontamination work		(per 1,300 m²) Tools, equipment to use / Quantity: Mowers (shoulder-type, cutter diameter 255 mm): 6.5 service days Light oil: 0.2 service days Sand paper, grinder, etc.: 7.4 L Gasoline: 18.6 L Large sandbags: -
Workforce needed		(per 1,300 m²) Workforce needed / Quantity: Operation leaders: 1.8 worker-days Specialized decontamination workers: 3.5 worker-days Decontamination workers: 8.2 worker-days Drivers (special decontamination): 0.2 worker-days
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● Before sediment removal, weeds, which can impede the work, shall be removed by using a shoulder-type mower or by hand. ● The amount of sediment removal (depth to be removed) shall be determined by test trials. ● When decontaminating slopes with a cut

(per 1,300 m^2)

Tools, equipment to use	Quantity
Mowers (shoulder-type, cutter diameter 255 mm)	6.5 service days
Light oil	0.2 service days
Sand paper, grinder, etc.	7.4 L
Gasoline	18.6 L
Large sandbags	-

(per 1,300 m^2)

Workforce needed	Quantity
Operation leaders	1.8 worker-days
Specialized decontamination workers	3.5 worker-days
Decontamination workers	8.2 worker-days
Drivers (special decontamination)	0.2 worker-days

		surface, the conditions of any nets shall be checked before the work. ● When working on long and big slopes, the area within about 20 m from the living space shall be covered with due attention to the usage status and other conditions of surrounding areas. ● When the slopes need protective measures of vegetation, appropriate construction methods shall be chosen in accordance with the "Guidelines of road construction methods for slope protection and stabilization (June 2009, Japan Road Association)
	Radiation exposure protection of workers	● Safety glasses, dust masks, gloves, etc. shall be worn.
	General labor safety of workers	● When working on steep slopes and bad footing slopes, slip prevention measures shall be ensured by using fixed ropes, safety belts, sliding devices on fixed ropes, etc. ● For work on roadside slopes, barricades and traffic controllers shall be arranged.
	Measures to prevent secondary wastes	–
	Others	The following points shall be noted when collecting contaminated objects on slopes: ● Transfer methods of large sandbags containing contaminated materials removed on the slopes (especially transfer upward) ● Crossing methods of rivers, brooks and the like ● Necessary consultations with supervisors on these collection methods

6.1.3. Rice Fields, Dry Fields, Pastures, etc.

（1） Weeds

1）Weeding by hand in rice fields and dry fields

Locations to be decontaminated	"8.1.1. Weeds" of "8.1. Rice fields" in "8. Farmland" "8.2.1. Weeds" of "8.2. Dry fields" in "8. Farmland"
Decontamination methods	Weed removal in rice fields and dry fields

Outline		Rice fields and dry fields shall be weeded using shoulder-type mowers or the like
Decontamination processes		● Weeds in rice fields and dry fields shall be removed by using shoulder-type mowers or the like
Tools, equipment and the like for decontamination work		Tools, equipment to use: Mowers (Shoulder-type, cutter diameter 255 mm) — Quantity: -
Workforce needed		(per 100 m²) Operation leaders: 0.02 worker-days Specialized decontamination workers: 0.23 worker-days
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● Weeds in narrow places, slopes and the like where large mechanized weeding equipment is not applicable.
	Radiation exposure protection of workers	● Protective equipment such as dust masks shall be properly worn to protect against dust blown up by mowers.
	作業員の一般労働安全対策	● Non-associated personnel shall be kept from the working place, as accidents often occur due to insufficient education on machinery use or kickbacks by mowers. ● To prepare for flying stones, protective equipment shall be properly worn, for example, wearing safety goggles and the like, or placing protective nets.
	Measures to prevent secondary wastes	–
	Others	–

2） Weeding by machines in rice fields and dry fields

Locations to be decontaminated	"8.1.1. Weeds" of "8.1. Rice fields" in "8. Farmland" "8.2.1. Weeds" of "8.2. Dry fields" in "8. Farmland"
Decontamination methods	Weeding by machines in rice fields and dry fields

Outline		Weeding by machines in rice fields and dry fields
Decontamination processes		● Weeds in rice fields and dry fields shall be removed using farm tractors or the like.
Tools, equipment and the like for decontamination work		(per 1,000 m^2) Tools, equipment to use / Quantity: Farm tractors (110PS, wheel-type): 0.27 service hours Off-set shredders (working width 200 cm): 0.04 service days Light oil: 3.0 L
Workforce needed		(per 1,000 m^2) Workforce needed / Quantity: Operation leaders: 0.01 worker-days Drivers (special decontamination): 0.05 worker-days
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● The work shall be done in areas which exceed a certain size (more than 1,000 m^2) and where machinery has no risks of overturning.
	Radiation exposure protection of workers	● Protective equipment such as dust masks shall be properly worn to protect against dust blown up.
	General labor safety of workers	● Safety measures shall be taken for the work with heavy machinery (proper arrangement for preventing minor collisions of adjacently working heavy machinery, and adequate instructions and supervision, as well as thorough control for preventing access to the machinery)
	Measures to prevent secondary wastes	–
	Others	–

3）Collection of weeds removed from rice fields and dry fields

Locations to be decontaminated	"8.1.1. Weeds" of "8.1. Rice fields" in "8. Farmland" "8.2.1. Weeds" of "8.2. Dry fields" in "8. Farmland"
Decontamination methods	Collection of contaminated weeds removed from rice fields and dry fields

Outline		Weeds removed from rice fields and dry fields shall be collected
Decontamination processes		● Weeds removed shall be collected by using hay collectors, packing machines for weeding, and other machines.
Tools, equipment and the like for decontamination work		(per 1,000 m²) Tools, equipment to use / Quantity Hay collectors (Hand guided-type, 120cm): 0.63 service days Packing machines for weeding (Hand guided-type, ϕ 500x700)): 0.59 service days Gasoline: 21.3 L
Workforce needed		(per 1,000 m²) Workforce needed / Quantity Operation leaders: 0.06 worker-days Drivers (special decontamination): 1.16 worker-days
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● The work shall be done in areas exceeding a certain size (more than 1,000 m²) and where machinery has no risks of overturning.
	Radiation exposure protection of workers	● Protective equipment such as dust masks shall be properly worn to protect against dust blown up.
	General labor safety of workers	● Safety measures shall be taken for work with heavy machinery (proper arrangement for preventing minor collisions of adjacently working heavy machinery, adequate instructions and supervision, as well as thorough control for preventing access to the machinery)
	Measures to prevent secondary wastes	–
	Others	–

(per 1,000 m^2)

Tools, equipment to use	Quantity
Hay collectors (Hand guided-type, 120cm)	0.63 service days
Packing machines for weeding (Hand guided-type, ϕ 500x700))	0.59 service days
Gasoline	21.3 L

(per 1,000 m^2)

Workforce needed	Quantity
Operation leaders	0.06 worker-days
Drivers (special decontamination)	1.16 worker-days

4）Weeding of grassland

Locations to be decontaminated	“8.3.1. Weeds” of “8.3. Grassland” in “8. Farmland”
Decontamination methods	Weeding of grassland

<table>
<tr><td colspan="2">Outline</td><td>Weeding of grassland</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>Weeds in grassland shall be removed by using farm tractors or the like.
Weeds removed shall be formed in roll bales.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td>(per ha)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Farm tractors (Riding-type, wheel-type, four-wheel drive, 52 -59kw class (70 – 80PS))</td><td>5.3
service hours</td></tr>
<tr><td>Flail mowers (Direct mount type) (1.5 m wide)</td><td>0.5
service days</td></tr>
<tr><td>Roll balers (1.0 m wide, 1.0 m tall)</td><td>0.1
service days</td></tr>
<tr><td>Rake (3.6 m wide)</td><td>0.1
service days</td></tr>
<tr><td>Beam sprayers (600 L, 12.3m Wide)</td><td>0.1
service days</td></tr>
<tr><td>Trucks (Load capacity 4.0 – 4.5 t)</td><td>0.3
service hours</td></tr>
<tr><td>Light oil</td><td>39.7L</td></tr>
<tr><td>Herbicide</td><td>5.0L</td></tr>
<tr><td>Water</td><td>0.6m^3</td></tr>
</table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per ha)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>0.17
worker-days</td></tr>
<tr><td>Drivers (ordinary decontamination)</td><td>1.1
worker-days</td></tr>
</table></td></tr>
<tr><td rowspan="3">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>The work shall be done in areas exceeding a certain size (more than 1,000 m^2) and where machinery has no risks of overturning.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>Protective equipment such as dust masks shall be properly worn to protect against dust blown up from weeding and roll discharging.</td></tr>
<tr><td>General labor safety of workers</td><td>Safety measures shall be taken for the work with heavy machinery (proper arrangement for preventing minor collisions of adjacently</td></tr>
</table>

		working heavy machinery, and adequate instructions and supervision, as well as thorough control for preventing access to the machinery)
	Measures to prevent secondary wastes	−
	Others	−

(2) Soil

1) Leveling of unevenness

Locations to be decontaminated	"8.1.2. Soil" of "8.1. Rice fields" in "8. Farmland" "8.2.2. Soil" of "8.2. Dry fields" in "8. Farmland"
Decontamination methods	Leveling of unevenness in rice fields and dry fields

Outline		Unevenness of soil in rice fields and dry fields shall be leveled.
Decontamination processes		● Unevenness of surface soil shall be leveled by using vibratory rollers or the like.
Tools, equipment and the like for decontamination work		(per 1,000 m²) Tools, equipment to use / Quantity Vibratory rollers (Riding-type combined roller 3 t, Exhaust gas suppression type (primary)) / 1.25 service hours Light oil / 3.8 L
Workforce needed		(per 1,000 m²) Workforce needed / Quantity Operation leaders / 0.02 worker-days Drivers (special decontamination) / 0.29 worker-days
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● Combined rollers shall not be used in flooded rice fields, because rollers sink in the fields and lose mobility ● Mobility of combined rollers shall be checked in advance. ● Basically no decontamination work shall be done during rain storms or in pooled water areas, because the surface layer of the arable land will be kneaded.
	Radiation exposure protection of workers	● Dust masks, gloves, etc. shall be worn
	General labor safety of workers	● No one other than the operation leader and the designated driver is allowed to enter the fields to level the unevenness with combined rollers. ● Existing access routes, if suitable, shall be used for entering the field for leveling the unevenness. ● If no access route is available, the combined

		roller shall enter the field slowly at a right angle to the ridge along the field. This is to avoid the roller overturning. ● If the slope of the entry route crossing the ridge along the field is too steep, a new entry route shall be constructed in order to prevent the roller from overturning. ● It shall be checked that no new big holes were made by wild bores or the like after weeds were removed and collected.
	Measures to prevent secondary wastes	−
	Others	−

2）Spreading surface solidifiers

Locations to be decontaminated	"8.1.2. Soil" of "8.1. Rice fields" in "8. Farmland" "8.2.2. Soil" of "8.2. Dry fields" in "8. Farmland"
Decontamination methods	Spreading surface solidifiers

Outline		Surface solidifiers shall be spread on the soil of rice fields and dry fields
Decontamination processes		● Solidifier solution shall be spread on the soil by using a seed scatterer or the like. The surface soil shall be checked as firmly solidified. ● The following conditions are assumed for surface soil solidification: the amount of solidifier 15 t/ha, the depth of solidification 2 – 3 cm, solidification time required 7 days (consecutive dry days). ● The water to prepare the solidifier solution (solvent) shall be checked in advance that no radioactive materials can be detected in it.
Tools, equipment and the like for decontamination work		(per 1,000 m^2) (see table below)
Workforce needed		(per 1,000 m^2) (see table below)
Idea	Prerequisites and	● No work shall be done in winter, as the

Tools, equipment and the like for decontamination work (per 1,000 m^2)

Tools, equipment to use	Quantity
Seeders (Riding-type , 1.0 m^3)	2.14 service hours
Air compressors (25PS, 0.7 MPa, 2.5 m^3/min)	0.36 service days
Crane truck (Load capacity 4 t, suspension weight 2.9 t)	3.25 service hours
Sprinkler truck (Tank capacity 3,800 L)	1.11 service hours
Light oil	36.9 L
Surface solidifier (neutral)	1.5 t

Workforce needed (per 1,000 m^2)

Workforce needed	Quantity
Operation leaders	0.26 worker-days
Specialized decontamination workers	0.62 worker-days
Decontamination workers	0.31 worker-days
Drivers (special decontamination)	0.56 worker-days
Drivers (ordinary decontamination)	0.22 worker-days

development, lessons, points to keep in mind, etc.	constraints regarding objects and locations to be decontaminated	solidifier does not work. ● Weather conditions affect the time required for solidification. ● No spreading of solidifier shall be allowed on water retaining spots.
	Radiation exposure protection of workers	● Safety glasses, dust masks, etc. shall be worn.
	General labor safety of workers	● The worker controlling the nozzle and the assistant must wear safety glasses to prevent solidifiers from entering the eyes. ● The nozzle shall be firmly held so as not to be whipped about by the hose pressure. ● After the hose is firmly held, the signal shall be given to start spreading of solidifiers. ● The moving parts of the seed scatterer shall be covered to prevent the operator from being caught in them.
	Measures to prevent secondary wastes	● The solidifiers shall be procured in flexible containers.
	Others	–

3）Scraping the surface soil

Locations to be decontaminated	"8.1.2. Soil" of "8.1. Rice fields" in "8. Farmland" "8.2.2. Soil" of "8.2. Dry fields" in "8. Farmland" "8.3.2. Soil" of "8.3. Grassland" in "8. Farmland"
Decontamination methods	Scraping of surface soil (standard transfer method)

Outline	Surface soil of rice fields, dry fields and grassland shall be scraped away (standard transfer method)
Decontamination processes	● The surface soil shall be scraped away by using backhoes or the like (to about 5 cm depth)
Tools, equipment and the like for decontamination work	When scraping the surface soil in big areas of more than 30a, (per 100 m^2) Tools, equipment to use / Quantity: Backhoes (Crawler-type, exhaust gas suppression (primary), Bucket capacity 0.45 m^3 when heaped (0.35 m^3, when flatly filled)) — 0.48 service hours Light oil — 5.3 L *This applies when topography and field conditions are relatively favorable and the area has about 30a in regular shape. ■When scraping the surface soil in small areas of less than 30a, (per 100 m^2) Tools, equipment to use / Quantity: Backhoe (Crawler-type, exhaust gas suppression (primary), Bucket capacity 0.45 m^3 when heaped (0.35 m^3, when flatly filled)) — 0.56 service hours Light oil — 6.2 L *This applies when the field conditions are not favorable, e.g., the field is not regular in shape.
Workforce needed	■When scraping the surface soil in big areas of more than 30a, (per 100 m^2) Workforce needed / Quantity: Operation leaders — 0.03 worker-days Decontamination workers — 0.18 worker-days

		Drivers (special decontamination) — 0.08 worker-days *This applies when topography and field conditions are relatively favorable and the area is about 30a in regular shape. ■When scraping the surface soil in small areas of less than 30a, (per 100 m2) Workforce needed / Quantity Operation leaders — 0.09 worker-days Decontamination workers — 0.26 worker-days Driver (special decontamination) — 0.09 worker-days *This applies when the field conditions are not favorable, e.g., the field is not regular in shape.
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● No work shall be done in flooded rice fields.
	Radiation exposure protection of workers	● Masks, gloves, etc. shall be worn.
	General labor safety of workers	● The working areas shall be marked with color cones, color cone bars, etc. for access control in order to prevent minor collisions between backhoes.
	Measures to prevent secondary wastes	－
	Others	● Banners or the like shall indicate where aerial wires run above farm roads or farmland, and a traffic controller shall be arranged in order to prevent damaging aerial wires when passing under them.

4）Deep plowing

<table>
<tr><td>Locations to be decontaminated</td><td>“8.1.2. Soil” of “8.1. Rice fields” in “8. Farmland”
“8.2.2. Soil” of “8.2. Dry fields” in “8. Farmland”
“8.3.2. Soil” of “8.3. Grassland” in “8. Farmland”</td></tr>
<tr><td>Decontamination methods</td><td>Deep plowing</td></tr>
</table>

<table>
<tr><td colspan="2">Outline</td><td>Soil in rice fields and grassland shall be plowed deeply</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>● The base mat shall be flattened by double plowing of surface soil by rotary tillers or the like.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td>(per 10,000 m²)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Farm tractors (Riding-type, wheel-type, four wheel driven 22kW-class (30PS)</td><td>26.0 service hours</td></tr>
<tr><td>Light oil</td><td>67.6 L</td></tr>
</table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per 10,000 m²)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Drivers (ordinary decontamination)</td><td>5.0 worker-days</td></tr>
</table></td></tr>
<tr><td rowspan="3">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● No work shall be done in flooded rice fields where the tractors may not be operable.
● Mobility of wheel-type tractors shall be checked in advance.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Masks, gloves, etc. shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>● No one other than the designated driver shall be allowed to enter the fields to plow deeply.
● Existing access routes, if suitable, shall be used for entering the fields.
● If no access route is available, the tractor shall enter the field slowly moving forward at a right angle to the ridge along the field. This is to avoid the tractor overturning.
● If the slope of the entry route crossing the ridge along the field is too steep, a new entry route shall be constructed in order to prevent the tractor from overturning.
● It shall be checked that no new big holes were made by wild bores or the like after weeds</td></tr>
</table>

		were removed and collected. ● Counter weights shall be attached to the tractor with a mounted rotary tiller, as appropriate, according to the instruction manual of the tractor when it enters or leaves the field (ascends or descends a ridge along the field), because the center of gravity of the tractor moves backward and the tractor is susceptible to overturning. ● A rotary tiller shall be mounted or demounted on a flat place such as a farm road with the tractor engine switched off. ● When doing maintenance on the rotary tiller, for example its cutting edges, not only the engine shall be switched off, but the rotary shall be locked and held from below by a table or the like to avoid its dropping suddenly.
	Measures to prevent secondary wastes	−
	Others	−

5）Deep tillage

Locations to be decontaminated	"8.1.2. Soil" of "8.1. Rice fields" in "8. Farmland" "8.2.2. Soil" of "8.2. Dry fields" in "8. Farmland" "8.3.2. Soil" of "8.3. Grassland" in "8. Farmland"
Decontamination methods	Deep tillage

<table>
<tr><td colspan="2">Outline</td><td>Surface soil of rice fields, dry fields and grassland shall be tilled deeply.</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>● The fields shall be tilled twice (tillage depth of about 30 cm) by using a deep tilling rotary tiller.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td>(per 10,000 m²)
<table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Farm tractors (Riding-type, wheel-type four wheel driven 52 - 59kw-class (70 - 80PS), 22kw-class (30PS)</td><td>4.3 service days</td></tr><tr><td>Light oil</td><td>60.0 L</td></tr></table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per 10,000 m²)
<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Drivers (ordinary decontamination)</td><td>4.0 worker-days</td></tr></table></td></tr>
<tr><td rowspan="3">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● The farmland where the soil was stirred by plowing after the accident shall be tilled in reverse or deeply.
● Deep tillage may damage the roots in orchards, tea plantations and other farmland where perennial produce is planted.
● If the ground below the tilling depth is rudaceous, precautions shall be taken, for example, to remove the gravel beforehand because the gravel may come up in the tilling layer by deep tillage.
● The underground water level shall be measured, if required, so necessary precautions may be taken in deep tilling.
● When the surface soil is frozen due to low temperatures, small-size tractors may not be sufficient for deep tilling.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Safety glasses, dust masks, rubber gloves, etc. shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>● No one other than the designated driver shall be allowed to enter the fields to till deeply.</td></tr>
</table>

		● Existing access routes, if suitable, shall be used for entering fields. ● If no access route is available, the tractor shall enter the field slowly moving forward at a right angle to the ridge along the field. This is to avoid the tractor overturning. ● If the slope of the entry route crossing the ridge along the field is too steep, a new entry route shall be constructed in order to prevent the tractor from overturning. ● It shall be checked that no new big holes were made by wild bores or the like after weeds were removed and collected. ● Counter weights shall be attached to the tractor with a mounted rotary tiller, as appropriate, according to the instruction manual of the tractor when it enters or leaves the field (ascends or descends a ridge along the field), because the center of gravity of the tractor moves backward and the tractor is susceptible to overturning. ● A rotary tiller shall be mounted or demounted on a flat place such as a farm road with the tractor engine switched off. ● When doing maintenance on the rotary tiller, for example its cutting edges, not only the engine shall be switched off, but the rotary shall be locked and held from below by a table or the like to avoid its dropping suddenly.
	Measures to prevent secondary wastes	–
	Others	–

6）Soil replacement

Locations to be decontaminated	"8.1.2. Soil" of "8.1. Rice fields" in "8. Farmland" "8.2.2. Soil" of "8.2. Dry fields" in "8. Farmland" "8.3.2. Soil" of "8.3. Grassland" in "8. Farmland"
Decontamination methods	Soil replacement

<table>
<tr><td>Outline</td><td>Surface soil of rice fields, dry fields and the like shall be replaced with fresh soil in the following procedures.
(i) Bringing in and spreading fresh soil
(ii) Short transferring of fresh soil to narrow places and spreading.
(iii) Compacting</td></tr>
<tr><td>Decontamination processes</td><td>● After scraping the soil off the surface, heavy machinery shall be used for replacing, spreading and leveling the fresh soil back to the original elevation.
● The MOE supervisory personnel shall be consulted for determining the quality of replacing fresh soil.
● Results of soil tests including grain sizes and radioactive material concentration measurement in the replacement fresh soil shall be reviewed and approved before use by the MOE supervisory personnel.</td></tr>
<tr><td>Tools, equipment and the like for decontamination work</td><td>(per 1,000 m²)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Shovels and the like</td><td>-</td></tr>
<tr><td>Backhoes (Crawler-type, exhaust gas suppression (secondary), Bucket capacity 0.28 m³ when heaped (0.20m³, when flatly filled))</td><td>1.1 service days</td></tr>
<tr><td>Vibratory rollers (Exhaust gas suppression (primary), combined type 3 – 4 t)</td><td>1.5 service days</td></tr>
<tr><td>Vibratory rollers (Exhaust gas suppression (primary), combined type 3 – 4 t)</td><td>0.4 service day</td></tr>
<tr><td>Dump trucks (Load capacity 2 t)</td><td>1.8 service days</td></tr>
<tr><td>Light oil</td><td>106.6 L</td></tr>
<tr><td>Fresh soil</td><td>55.5 m³</td></tr>
</table></td></tr>
</table>

<table>
<tr><td colspan="2">Workforce needed</td><td>(per 1,000 m²)
<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>0.7 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>0.4 worker-days</td></tr><tr><td>Decontamination workers</td><td>4.7 worker-days</td></tr><tr><td>Drivers (special decontamination)</td><td>2.6 worker-days</td></tr><tr><td>Drivers (ordinary decontamination)</td><td>1.5 worker-days</td></tr></table></td></tr>
<tr><td rowspan="5">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Differences shall be noted between the surface soil stirred by plowing and that not plowed after the accident. Even if the radioactive concentration is equal, the air dose rate is higher above the unplowed soil which keeps the surface as it was.
● The soil replacement and other measures needed shall be implemented after decontamination, soil analysis and diagnosis.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Safety glasses, dust masks, rubber gloves, etc. shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>● Existing access routes, if suitable, shall be used for entering the fields.
● If no access route is available, the heavy machinery shall enter the field slowly moving forward at a right angle to the ridge along the field. This is to avoid the heavy machinery overturning.
● If the slope of the entry route crossing the ridge along the field is too steep, a new entry route shall be constructed in order to prevent the heavy machinery from overturning.
● It shall be checked that no new big holes were made by wild bores or the like by which the heavy machinery might be overturned.</td></tr>
<tr><td>Measures to prevent secondary wastes</td><td>–</td></tr>
<tr><td>Others</td><td>–</td></tr>
</table>

7）Restoration of soil fertility

Locations to be decontaminated	"8.1.2. Soil" of "8.1. Rice fields" in "8. Farmland" "8.2.2. Soil" of "8.2. Dry fields" in "8. Farmland" "8.3.2. Soil" of "8.3. Grassland" in "8. Farmland"
Decontamination methods	Restoration of soil fertility

<table>
<tr><td>Outline</td><td>Soil fertility of rice fields, dry fields and grassland shall be restored by spreading soil conditioners or zeolite.</td></tr>
<tr><td>Decontamination processes</td><td>● Soil conditioners shall be sprayed by a sprinkler mounted on a tractor.
● Soil conditioners shall be those reported to the Governor of Fukushima Prefecture as special fertilizers pursuant to the Fertilizer Control Law (Law No. 127, 1950) and those which can increase soil fertility by integrated improvement of physicochemical and biological properties of the soil.
● The soil conditioners shall be approved by the supervisory MOE personnel in advance through test results.
● Zeolite may be used in place of the soil conditioners.</td></tr>
<tr><td>Tools, equipment and the like for decontamination work</td><td>■ When spraying soil conditioners,
(per 10,000 m²)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Construction tractors (Ordinary type, load capacity 9 t)</td><td>1.1 service hours</td></tr>
<tr><td>Lime spreaders [138] (Towing capacity 800 L, spray span 3 m class)</td><td>1.1 service hours</td></tr>
<tr><td>Light oil</td><td>13.0 L</td></tr>
<tr><td>Soil conditioner (calcium carbonate)</td><td>Depending on soil properties</td></tr>
<tr><td>Soil conditioner (potassium silicate)</td><td>0.8 t</td></tr>
</table>
*Machinery for spraying soil conditioners

■ When spraying zeolite,
(per 1,000 m²)
<table>
<tr><th>Tools, equipment to use</th><th>Quantity</th></tr>
<tr><td>Farm tractor (Crawler-type, 40PS)</td><td>0.56 service hours</td></tr>
</table>
</td></tr>
</table>

[138] Machines for dispersion of fertilizer and soil improving agent

<table>
<tr><td></td><td>
<table>
<tr><td>Lime spreaders (Spray span 1.8 m class)</td><td>0.1 service days</td></tr>
<tr><td>Light oil</td><td>4.3 L</td></tr>
<tr><td>Zeolite</td><td>0.5 t</td></tr>
</table>
</td></tr>
<tr><td>Workforce needed</td><td>
■ When spraying soil conditioners,
(per 10,000 m^2)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>0.2 worker-days</td></tr>
<tr><td>Decontamination workers</td><td>0.77 worker-days</td></tr>
<tr><td>Drivers (special decontamination)</td><td>0.17 worker-days</td></tr>
</table>
■ When spraying zeolite,
(per 1,000 m^2)
<table>
<tr><th>Workforce needed</th><th>Quantity</th></tr>
<tr><td>Operation leaders</td><td>0.15 worker-days</td></tr>
<tr><td>Specialized decontamination workers</td><td>0.09 worker-days</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td rowspan="5">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Upon completion of decontamination and analysis, the amount of soil conditioners or zeolite shall be determined.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Safety glasses, dust masks, rubber gloves, etc. shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>● Existing access routes, if suitable, shall be used for entering the farmland.
● If no access route is available, the heavy machinery shall enter the field slowly moving forward at a right angle to the ridge along the field.
● If the slope of the entry route crossing the ridge along the field is too steep, a new entry route shall be constructed in order to prevent the heavy machinery from overturning.
● It shall be checked that no new big holes were made by wild bores or the like by which the heavy machinery might be overturned.</td></tr>
<tr><td>Measures to prevent secondary wastes</td><td>–</td></tr>
<tr><td>Others</td><td>–</td></tr>
</table>

（3） Waterways

1） Removal of bottom sediment (soil suctioning)

Locations to be decontaminated	"8.4.1. Waterways" of "8.4. Waterways" in "8. Farmland"
Decontamination methods	Removal of bottom sediment (soil suctioning) from waterways in farmland

<table>
<tr><td colspan="2">Outline</td><td>Bottom sediment in waterways of farmland shall be removed (soil suctioning)</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>● Sediment easily removable such as fallen leaves, moss, mud, etc. shall be removed by using shovels and the like.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td><table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Shovels and the like</td><td>-</td></tr></table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per 10 m³)<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>0.21 worker-days</td></tr><tr><td>Decontamination workers</td><td>8.37 worker-days</td></tr></table></td></tr>
<tr><td rowspan="2">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Most work for removing bottom sediment in waterways of farmland is done in narrow spaces and shall be done by hand. The bottom sediment collected shall be immediately packed in small bags nearby and transferred by hand. The small bags shall be such that hand-carry belts may be used for easy transfer in bad footing spaces (570×530×H550).
● If the waterway has flow, the working zone shall be dammed upstream and downstream to block the flow. A hand-carry water-immersed pump (2B, discharge amount 0.1 – 0.12 m³/min) shall be used so that the removal work can be done in no-flow conditions.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● The air dose rate in working areas shall be clearly indicated to the workers.
● The air dose rate in the working areas for decontamination shall be measured in advance, and if the dose rate is high, the area shall be so indicated by using color cones, color cone bars and the like.</td></tr>
</table>

		● Daily and accumulated exposure doses of individual workers shall be indicated in an easily understandable way and kept under control. ● Unnecessary access to places with large packed sandbags shall be restricted because of their high dose rate risk. ● Protective equipment such as disposable masks, rubber gloves, etc. shall be disposed of at the pre-designated spots when the work is finished.
	General labor safety of workers	● Protective equipment (masks, gloves and the like) shall be appropriately worn. ● Special attention shall be paid to footwear of workers transferring packed bags and the like, since the waterways in farmland are muddy and there are slopes or ridges along fields where workers may slip.
	Measures to prevent secondary wastes	–
	Others	● When leaving the working areas, contamination on body surfaces shall be checked as lower than 1,300 cpm by screening, which is stricter than the allowable limit of 13,000 cpm.

2）Removal and the like of bottom sediment (Packing)

Locations to be decontaminated	"8.4.1. Waterways" of "8.4. Waterways" in "8. Farmland"
Decontamination methods	Removal of bottom sediment in waterways of farmland (Packing)

<table>
<tr><td colspan="2">Outline</td><td>Bottom sediment in waterways in farmland shall be removed (and packed).</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>● Bottom sediment collected shall be packed in large sandbags by hand.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td><table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Large sandbags</td><td>-</td></tr></table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per 10 bags)<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>0.11 worker-days</td></tr><tr><td>Decontamination workers</td><td>1.68 worker-days</td></tr></table></td></tr>
<tr><td rowspan="2">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Large sandbags may lose their shape, when being packed with collected sediment, due to difficulty of uniform filling. For shape keeping and easy packing, large sandbags shall be filled on a dedicated table.
● Bottom sediment has high water content. In order to prevent contaminated water from leaking, an inner bag shall be placed in the large sandbags, or water-proof flexible containers shall be used.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● The air dose rate in working areas shall be clearly indicated to the workers.
● The air dose rate in the area for decontamination shall be measured in advance, and if the dose rate is high, the area shall be so indicated by using color cones, color cone bars and the like.
● Daily and accumulated exposure doses of individual workers shall be indicated in an easily understandable way and kept under control.
● Whenever sand or the like is attached (deposited) on workers' clothing or protective equipment, sand or the like shall be wiped away immediately in order to prevent contamination from spreading.
● Unnecessary access to places with large</td></tr>
</table>

		packed sandbags shall be restricted because of their high dose rate risk. ● Protective equipment such as disposable masks, rubber gloves, etc. shall be disposed of at the pre-designated spots when the work is finished.
	General labor safety of workers	● Protective equipment (masks, gloves and the like) shall be appropriately worn. ● Special attention shall be paid to footwear of workers transferring packed bags and the like, since the waterways in farmland are muddy and there are slopes or ridges along fields where workers may slip. ● Safety systems and equipment shall be checked before commencing the day's work. ● When using backhoes for packing, access to the rotating range shall be prohibited in order to prevent minor collisions.
	Measures to prevent secondary wastes	–
	Others	● When leaving the working areas, contamination on body surfaces shall be checked as lower than 1,300 cpm by screening, which is stricter than the allowable limit of 13,000 cpm.

（4） Others

1） Packing (standard transfer process)

Locations to be decontaminated	"8.1.2. Soil" of "8.1. Rice fields" in "8. Farmland" "8.2.2. Soil" of "8.2. Dry fields" in "8. Farmland" "8.3.2. Soil" of "8.3. Grassland" in "8. Farmland"
Decontamination methods	Packing (standard transfer process)

<table>
<tr><td colspan="2">Outline</td><td>Soil removed from rice fields, dry fields or grassland in farmland shall be packed for transfer (standard transfer process)</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>● The soil removed shall be collected and packed in large sandbags by using backhoes or the like.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td>(per 10 bags)
<table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Backhoes (Exhaust gas suppression (primary), crawler type, Bucket capacity 0.45 m³ when heaped up, 0.35 m³ when flatly filled)</td><td>1.42 service hours</td></tr><tr><td>Light oil</td><td>16.0 L</td></tr><tr><td>Large sandbags</td><td>-</td></tr></table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per 10 bags)
<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>0.06 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>0.21 worker-days</td></tr><tr><td>Decontamination workers</td><td>0.24 worker-days</td></tr><tr><td>Driver (special decontamination)</td><td>0.23 worker-days</td></tr></table></td></tr>
<tr><td rowspan="3">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Special attachments shall be fabricated for packing into large sandbags.
● Lined up heights of large sandbags after being filled shall be leveled.</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Safety glasses, dust masks, gloves, etc. shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>● The work proceeds next to heavy machinery. The working range of the heavy machinery shall be clearly indicated and supervising personnel shall be arranged.</td></tr>
</table>

		● Safety education shall be provided to the workers on nearby parallel work with heavy machinery.
	Measures to prevent secondary wastes	● Twigs, protrusions or the like in the sediment collected shall be removed before being packed in large sandbags to prevent bag breaks.
	Others	–

2）Small transfer within the working fields (standard transfer process)

Locations to be decontaminated	"8.1.2. Soil" of "8.1. Rice fields" in "8. Farmland" "8.2.2. Soil" of "8.2. Dry fields" in "8. Farmland" "8.3.2. Soil" of "8.3. Grassland" in "8. Farmland"
Decontamination methods	Small transfer (standard transfer process)

Outline		Contaminated soil removed from farmland (rice fields, dry fields and grassland) shall be transferred short distances in small amounts (standard transfer process) within the working fields.
Decontamination processes		● Crane backhoes, rough terrain haulers or the like shall be used for small and short transfers in the working fields (loading, unloading)
Tools, equipment and the like for decontamination work		(per 10 bags) see table below
Workforce needed		(per 10 Bags) see table below
Idea development,	Prerequisites and constraints regarding	● Transfer paths easily get muddy in rain. Iron sheets or the like shall be needed to cover the

Tools, equipment and the like for decontamination work (per 10 bags)

Tools, equipment to use	Quantity
Crane backhoes (Exhaust gas suppression (primary), crawler type, Bucket capacity 0.28 m^3 when heaped up (0.25 m^3 when flatly filled))	1.3 service hours
Crane backhoes (Exhaust gas suppression (primary), crawler type, Bucket capacity 0.45 m^3 when heaped up (0.35 m^3 when flatly filled))	0.28 service hours
Rough terrain haulers (Exhaust gas suppression (primary), crawler type, load capacity 4 t)	0.18 service days
Light oil	31.5 L

* per short transfer distance L=100 m (round trip)

Workforce needed (per 10 Bags)

Workforce needed	Quantity
Operation leaders	0.06 worker-days
Specialized decontamination workers	0.23 worker-days
Drivers (special decontamination)	0.44 worker-days

* per short transfer distance L=100 m (round trip)

lessons, points to keep in mind, etc.	objects and locations to be decontaminated	muddy paths used for transfer.
	Radiation exposure protection of workers	• Safety glasses, dust masks, gloves, etc. shall be worn.
	General labor safety of workers	• Clear indication of transfer paths. • The work proceeds next to heavy machinery or vehicles. The working range of the heavy machinery shall be clearly indicated and supervising personnel shall be arranged. • Safety education shall be provided to the workers on nearby parallel work with heavy machinery and vehicles.
	Measures to prevent secondary wastes	–
	Others	–

6.1.4. Grassland, Lawns

1) Cutting down shrubs (dense)

Locations to be decontaminated	"9.1.1. Shrubs (dense)" of "9.1. Shrubs (dense)" in "9. Grassland, lawns"
Decontamination methods	Cutting down shrubs (dense)

<table>
<tr><td colspan="2">Outline</td><td>Shrubs (dense) in grassland and lawns shall be cut down in the following procedures.
(i) Cutting down shrubs
(ii) Small amount and short distance transfer in the working fields
(iii) Packing of cut shrubs</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>● Large weeds, shrubs and the like shall be cut down by chainsaws and the like and be packed in large sandbags.
● Cut shrubs and the like too large to pack in large sandbags shall be chopped into packable sizes, or cut in about 2 m long pieces after removing leaves with a hatchet and tied using strings or the like in about 30 cm diameter bundles. The removed leaves shall be packed in large sandbags.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td>(per 1,000 m²)<table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Cutters (Chainsaw, edge 600 mm long (80 cc))</td><td>13.3 service days</td></tr><tr><td>Gasoline</td><td>16.8 L</td></tr><tr><td>Large sandbags</td><td>-</td></tr></table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per 1,000 m²)<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>3.6 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>5.3 worker-days</td></tr><tr><td>Decontamination workers</td><td>16.7 worker-days</td></tr></table></td></tr>
<tr><td>Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● The geometry of grassland and lawns is diverse. Depending on the work site situation, the spot for packing into large sandbags, transfer paths, loading stations, etc. shall be chosen and designated. Flat spaces shall be chosen for packing and temporary storage in order to ensure working safety.
● Worker safety shall be ensured before</td></tr>
</table>

		starting cutting by designating safe working and transfer paths. ● Basically chainsaws shall be used for cutting in dense shrub areas. Shrubs cut down shall be pruned to carriable sizes and be carried out for collection after removing branches. ● When cutting down tall bamboo trees, the cut bamboo may be impediments to working. The cut bamboo trees shall be carried out as they are and be pruned elsewhere. ● When packing, branches or the like may damage the large sandbags. To prevent sandbags being damaged, shrubs shall be cut so that no sharp cut ends are left. ● Large sandbags may lose shape, when being packed with collected cut materials, due to difficulty of uniform filling. For shape keeping and easy packing, the large sandbags shall be filled on a dedicated table.
	Radiation exposure protection of workers	● The air dose rate in working areas shall be clearly indicated to the workers. ● The air dose rate in the area for decontamination shall be measured in advance, and if the dose rate is high, the area shall be indicated by using color cones, color cone bars and the like. ● Daily and accumulated exposure doses of individual workers shall be indicated in an easily understandable way and kept under control. ● When collecting cut branches and leaves, rakes or the like shall be used in order to prevent direct handling to the extent possible. ● Unnecessary access to places with large packed sandbags shall be restricted because of their high dose rate risk. ● Protective equipment such as disposable masks, rubber gloves, etc. shall be disposed of at the pre-designated spots when the work is finished.
	General labor safety of workers	● Protective equipment (masks, gloves and the like) shall be appropriately worn. ● Safety systems and equipment shall be checked before commencing the day's work. ● When using backhoes for packing, the access to the rotating range shall be prohibited in order to prevent minor collisions. ● Safety glasses shall be properly worn, when packing, to prevent branches from poking the eyes.

		• When cutting, flying stones or rotating edges may hurt nearby workers. To prevent the, the working zones shall be set apart with an interval of about 10 to 15 m, and the work shall be done under a foreman's supervision. • When working on vibratory machines such as chain saws and weed cutters, a rest of more than 5 min shall be taken each 30 min in order to prevent vibration hazard. • When working with hatchets for cutting, a suitable distance shall be kept from neighboring workers.
	Measures to prevent secondary wastes	–
	Others	• When leaving the working areas, contamination on body surfaces shall be checked as lower than 1,300 cpm by screening, which is stricter than the allowable limit of 13,000 cpm.

2) Cutting down shrubs (sparse)

Locations to be decontaminated	"9.2.1. Shrubs (sparse)" of "9.1. Shrubs (sparse)" in "9. Grassland, lawns"
Decontamination methods	Cutting down shrubs (sparse) in grassland, lawns

<table>
<tr><td colspan="2">Outline</td><td>Shrubs (sparse) in grassland and lawns shall be cut in the following procedures.
(i) Cutting down shrubs
(ii) Small amount and short distance transfer in the working fields
(iii) Packing cut shrubs</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>● Weeds, shrubs and the like shall be cut down by shoulder-type mowers and the like and be packed in large sandbags.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td>(per 1,000 m²)
<table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Mowers (Shoulder-type, cutter 255 mm, 1.3 kW class)</td><td>2.0 service days</td></tr><tr><td>Gasoline</td><td>5.7L</td></tr><tr><td>Large sandbags</td><td>-</td></tr></table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per 1,000 m²)
<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>3.1 worker-days</td></tr><tr><td>Specialized decontamination workers</td><td>1.1 worker-days</td></tr><tr><td>Decontamination workers</td><td>7.0 worker-days</td></tr></table></td></tr>
<tr><td>Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● The geometry of grassland and lawns is diverse. Depending on the field situation, the spot for packing into large sandbags, transfer paths, loading stations, etc. shall be chosen and designated. Flat spaces shall be chosen for packing and temporary storage in order to ensure working safety.
● Work safety shall be ensured before starting cutting by designating safe working and transfer paths.
● Shoulder-type mowers shall be used for cutting in sparse shrub areas. Too large shrubs to cut by mowers shall be cut by chainsaws.
● When cutting down tall bamboo trees, the cut bamboo may be impediments to working. The</td></tr>
</table>

		cut bamboo trees shall be carried out as they are and be pruned elsewhere. ● When packing, branches or the like may damage the large sandbags. To prevent this, shrubs shall be cut so that no sharp cut ends are left. ● Large sandbags may lose their shape, when being packed with collected scrubs, due to difficulty of uniform filling. For shape keeping and easy packing, the large sandbags shall be filled on a dedicated table.
	Radiation exposure protection of workers	● The air dose rate in working areas shall be clearly indicated to the workers. ● The air dose rate in the area for decontamination shall be measured in advance, and if the dose rate is high, the areas shall be so indicated by using color cones, color cone bars and the like. ● Daily and accumulated exposure doses of individual workers shall be indicated in an easily understandable way and kept under control. ● When collecting cut branches and leaves, rakes or the like shall be used in order to prevent direct handling to the extent possible. ● Unnecessary access to places with large packed sandbags shall be restricted because of their high dose rate risk. ● Protective equipment such as disposable masks, rubber gloves, etc. shall be disposed of at the pre-designated spots when the work is finished.
	General labor safety of workers	● Protective equipment (masks, gloves and the like) shall be appropriately worn. ● Safety systems and equipment shall be checked before commencing the day's work. ● When using backhoes for packing, the access to the rotating range shall be prohibited in order to prevent minor collisions. ● Safety glasses shall be properly worn, when packing, to prevent branches from poking the eyes. ● When cutting, flying stones or rotating edges may hurt nearby workers. To prevent this, the working zones shall be set apart with an interval of about 10 to 15 m, and the work shall be done under a foreman's supervision. ● When working on vibratory machines such as mowers and weed cutters, a rest of more than 5 min shall be taken each 30 min in order to prevent vibration hazard.

		● When working with hatchets for cutting, a suitable distance shall be kept from neighboring workers.
	Measures to prevent secondary wastes	−
	Others	● When leaving the working areas, contamination on body surfaces shall be checked as lower than 1,300 cpm by screening, which is stricter than the allowable limit of 13,000 cpm.

6.1.5. Forests

（1） Items common to the forests with mixed trees of coniferous evergreen trees, deciduous broad-leaf trees and others

1）Removal of sediment (organic materials)

Locations to be decontaminated	"11.1.1. Sediment (organic materials)" of "11.1. Coniferous evergreen trees" in "11. Forests" "11.2.1. Sediment (organic materials)" of "11.2. Deciduous broad-leaf trees" in "11. Forests" "11.3.1. Sediment (organic materials)" of "11.3. Forests with mixed trees" in "11. Forests"
Decontamination methods	Removal of Sediment (organic materials)

Outline	Sediment (organic materials) of forests (coniferous evergreen trees, deciduous broad-leaf trees, other mixed trees, etc.) shall be removed in the following procedures. (i) Removing organic materials such as fallen leaves (ii) Small and short transfer in working fields (iii) Packing removed organic materials
Decontamination processes	● Fallen leaves, fallen branches and the like in a layer about 5 cm deep from the surface shall be collected and carried by rakes or the like to the bottom edge of slopes and be packed in large sandbags. The removal should not be as deep as to reach the mineral soil layer. ● Fallen branches or the like too big to pack in large sandbags as they are shall be chopped into packable sizes, or cut into about 2 m long pieces and bundled using strings or the like in about 30 cm diameter bundles.
Tools, equipment and the like for decontamination work	(see table below)
Workforce needed	■ ■ When working on cedar trees among coniferous evergreen trees, (per 10,000 m^2) (see table below)

Tools, equipment and the like for decontamination work:

Tools, equipment to use	Quantity
Rakes or the like	-
Large sandbags	-

Workforce needed — ■ ■ When working on cedar trees among coniferous evergreen trees,

(per 10,000 m^2)

Workforce needed	Quantity
Operation leader	21.1 worker-days
Decontamination workers (for removing organic materials)	86.1 worker-days
Decontamination workers (small transfer)	31.6 worker-days

		<table><tr><td>Decontamination workers (packing into large sandbags)</td><td>22.8 worker-days</td></tr></table> ■ When working on Japanese cypress among coniferous evergreen trees (per 10,000 m^2) <table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>15.6 worker-days</td></tr><tr><td>Decontamination workers (for removing organic materials)</td><td>57.4 worker-days</td></tr><tr><td>Decontamination workers (small transfer)</td><td>31.6 worker-days</td></tr><tr><td>Decontamination workers (packing into large sandbags)</td><td>15.2 worker-days</td></tr></table> ■ When working on Japanese red pine and the like among coniferous evergreen trees, and other mixed trees, (per 10,000 m^2) <table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>20.5 worker-days</td></tr><tr><td>Decontamination workers (for removing organic materials)</td><td>83.2 worker-days</td></tr><tr><td>Decontamination workers (small transfer)</td><td>31.6 worker-days</td></tr><tr><td>Decontamination workers (packing into large sandbags)</td><td>22.0 worker-days</td></tr></table> ■ When working on Japanese emperor oak and the like among coniferous evergreen trees, (per 10,000 m^2) <table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>21.5 worker-days</td></tr><tr><td>Decontamination workers (for removing organic materials)</td><td>88.1 worker-days</td></tr><tr><td>Decontamination workers (small transfer)</td><td>31.6 worker-days</td></tr><tr><td>Decontamination workers (packing into large sandbags)</td><td>23.3 worker-days</td></tr></table>
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● Safety measures are occasionally difficult to take on steep slopes and the like. In such cases, decontamination work has been implemented, upon consultation with the ordering party, for individual working areas (for example, 2 m from the top of slopes or 2 m from the bottom of slopes).
	Radiation exposure protection of workers	● Safety glasses, masks and gloves shall be worn.

	General labor safety of workers	● In case general safety measures are insufficient to secure working safety, for example, on steep slopes, safety measures shall be strengthened depending on individual working conditions. ● Where risks of falling down or sliding down are present, safety measures shall be needed, for instance, installing fixed ropes and using fall arresting devices. ● If there are roads along the forest edge, barricades and traffic controllers shall be arranged.
	Measures to prevent secondary wastes	–
	Others	● As a preparatory measure for small transfer, workers shall be instructed to carry small empty sandbags when collecting organic materials.

2) Removal of Sediment (organic materials) (non-control areas)

Locations to be decontaminated	"11.1.1. Sediment (organic materials)" of "11.1. Coniferous evergreen trees" in "11. Forests" "11.2.1. Sediment (organic materials)" of "11.2. Deciduous broad-leaf trees" in "11. Forests" "11.3.1. Sediment (organic materials)" of "11.3. Forests with mixed trees" in "11. Forests"
Decontamination methods	Removal of Sediment (organic materials) (non-control areas)

Outline	Sediment (organic materials) of forests (coniferous evergreen trees, deciduous broad-leaf trees, forests with mixed trees, etc.) in non-control areas shall be removed in the following procedures. (i) Removing organic materials such as fallen leaves (ii) Small amount and short-distance transfer in working fields (iii) Packing removed organic materials
Decontamination processes	● Fallen leaves, fallen branches and the like in a layer about 10 cm deep from the surface shall be collected and carried using rakes or the like to the bottom edge of slopes and be packed in large sandbags. The removal should not be so deep as to reach the mineral soil layer. ● Fallen branches or the like too large to pack in large sandbags shall be chopped into packable sizes, or cut in about 2 m long pieces and bundled using strings or the like in about 30 cm diameter bundles
Tools, equipment and the like for decontamination work	(see table below)
Workforce needed	(see table below)

Tools, equipment to use	Quantity
Rakes or the like	-
Large sandbags	-

(per 10,000 m²)

Workforce needed	Quantity
Operation leaders	28.2 worker-days
Decontamination workers (for removing organic materials)	133.3 worker-days
Decontamination workers (small transfer)	31.6 worker-days
Decontamination workers (packing into large sandbags)	22.8 worker-days

*This applies when the organic material layer

		thickness exceeds 10 cm, irrespective of the tree types.
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● Safety measures are occasionally difficult to take on steep slopes and the like. In such cases, decontamination work has been implemented, upon consultation with the ordering party, for individual working areas (for example, 2 m from the top of slopes or 2 m from the bottom of slopes).
	Radiation exposure protection of workers	● Safety glasses, masks and gloves shall be worn.
	General labor safety of workers	● In case general safety measures are insufficient to secure working safety, for example, on steep slopes, safety measures shall be strengthened depending on individual working conditions. ● Where risks of falling down or sliding down are present, safety measures shall be needed, for instance, installing fixed ropes and using fall arresting devices. ● If there are roads along the forest edge, barricades and traffic controllers shall be arranged.
	Measures to prevent secondary wastes	–
	Others	● As a preparatory measure for small transfer, workers shall be instructed to carry small empty sandbags when collecting sediment.

3) Prevention of secondary dispersion of contaminated soil (lining up of sandbags)

Locations to be decontaminated	"11.1.2. Soil" of "11.1. Coniferous evergreen trees" in "11. Forests" "11.2.2. Soil" of "11.2. Deciduous broad-leaf trees" in "11. Forests" "11.3.2. Soil" of "11.3. Forests with mixed trees" in "11. Forests"
Decontamination methods	Prevention of secondary dispersion of contaminated soil (lining up of sandbags)

<table>
<tr><td colspan="2">Outline</td><td>Secondary dispersion of contaminated soil in forests (coniferous evergreen trees, deciduous broad-leaf trees, other mixed trees, etc.) shall be prevented by lining up sandbags.</td></tr>
<tr><td colspan="2">Decontamination processes</td><td>● When removing fallen leaves from steep slopes, sandbags shall be lined up at the forest edges in order to prevent soil from being eroded.
● Sandbags shall be lined up with their small tied end in front unless otherwise instructed.
● Sandbags of 48cm x 62cm (No. 2) shall be used and when packed shall measure approximately about 50cm x 40cm x 10cm.</td></tr>
<tr><td colspan="2">Tools, equipment and the like for decontamination work</td><td>(per 50 spots)<table><tr><th>Tools, equipment to use</th><th>Quantity</th></tr><tr><td>Shovels and the like</td><td>-</td></tr><tr><td>Sandbags (jute, 48 x 62 cm)</td><td>200 bags</td></tr><tr><td>mountain sand</td><td>4.0 m3</td></tr></table></td></tr>
<tr><td colspan="2">Workforce needed</td><td>(per 50 spots)<table><tr><th>Workforce needed</th><th>Quantity</th></tr><tr><td>Operation leaders</td><td>0.2 worker-days</td></tr><tr><td>Decontamination workers</td><td>1.5 worker-days</td></tr></table></td></tr>
<tr><td rowspan="3">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● Sandbags shall be lined up at the forest edge in order to prevent soil from eroding, when organic materials such as fallen leaves are removed from steep slopes in forests, or when soil erosion by rainfall is possible after the removal of sediment organic materials</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Dust masks, rubber gloves and the like shall be worn.</td></tr>
<tr><td>General labor safety of workers</td><td>● Protective measures shall be taken to prevent sliding down, such as fixed ropes, safety belts and sliding devices on fixed ropes.</td></tr>
</table>

	Measures to prevent secondary wastes	–
	Others	–

4) Cutting down underbrush and shrubs

Locations to be decontaminated	"11.1.4. Underbrush cutting" of "11.1. Coniferous evergreen trees" in "11. Forests" "11.2.4. Underbrush cutting" of "11.2. Deciduous broad-leaf trees" in "11. Forests" "11.3.4. Underbrush cutting" of "11.3. Forests with mixed trees" in "11. Forests"
Decontamination methods	Cutting down underbrush and shrubs

Outline	Underbrush and shrubs in forests (coniferous evergreen trees, deciduous broad-leaf trees, other mixed trees, etc.) shall be cut down.
Decontamination processes	● Underbrush and shrubs shall be cut down by using shoulder-type mowers and the like. The cut materials shall be collected at the forest edge and packed in large sandbags. ● Pieces too big to pack in large sandbags as they are shall be chopped into packable sizes, or cut into less than 2 m long pieces and tied using strings or the like in about 30 cm diameter bundles. The bundles shall be collected and piled up at the forest edge for subsequent processes (transfer to volume reduction facilities or volume reduction by wood crushers).
Tools, equipment and the like for decontamination work	(see table below)
Workforce needed	■ When the objects to be cut down are sparsely distributed, less than 17,000 pieces/ha (good visibility in the forests and easy to walk around), (per 10,000 m²)

Tools, equipment to use	Quantity
Sandbags	-

(per 10,000 m^2)

Workforce needed	Quantity		
	Slope 0 to 20°	Slope 21 to 30°	Slope > 31°
Operation leaders	1.1 worker-days	1.2 worker-days	1.3 worker-days
Decontamination workers	7.1 worker-days	7.7 worker-days	8.6 worker-days

■ When the objects to be cut down are intermediate in distribution, between 17,000 and 28,000 pieces/ha,

(per 10,000 m^2)

Workforce needed	Quantity		
	Slope 0 to 20°	Slope 21to 30°	Slope > 31°
Operation leaders	1.5 worker-days	1.6 worker-days	1.6 worker-days
Decontamination workers	10.0 worker-days	10.4 worker-days	10.9 worker-days

■ When the objects to weed are densely distributed, more than 28,000 pieces/ha (lots of underbrush, poor visibility in the forests and hard to walk around),

(per 10,000 m^2)

Workforce needed	Quantity		
	Slope 0 to 20°	Slope 21 to 30°	Slope > 31°
Operation leaders	1.9 worker-days	2.1 worker-days	2.2 worker-days
Decontamination workers	12.9 worker-days	13.7 worker-days	14.5 worker-days

Idea development, lessons, points to keep in mind, etc.

Prerequisites and constraints regarding objects and locations to be decontaminated

- This work is to improve visibility at the bases of trees in forests.

Radiation exposure protection of workers

- Dust masks, rubber gloves and the like shall be worn.
- The underbrush and shrubs are likely to have grown after the accident. The spot to place the cut materials collected shall be chosen carefully, because the air dose rate may increase after the cutting work

General labor safety of workers

- The mower edge may be hidden in the underbrush during cutting. Due attention shall be paid to the feet so as not to get cuts or injuries from the blade edges

Measures to prevent secondary wastes

–

Others

–

5）Removal of residual sediment (organic material)

Locations to be decontaminated	"11.1.5. Removal of residual sediment (organic materials)" of "11.1. Coniferous evergreen trees" in "11. Forests" "11.2.5. Removal of residual sediment (organic materials)" of "11.2. Deciduous broad-leaf trees" in "11. Forests" "11.3.5. Removal of residual sediment (organic materials)" of "11.3. Forests with mixed trees" in "11. Forests"
Decontamination methods	Removal of residual leaf litter and woody materials (organic materials)

Outline		Residual sediment (organic materials) in forests (coniferous evergreen trees, deciduous broad-leaf trees, other mixed trees, etc.) shall be removed.
Decontamination processes		● Where residual organic materials are left behind after removal work, they shall be collected by rakes or the like and be packed in large sandbags after being transferred to the bottom of the slope. ● The removal of residual organic materials should not be so deep as to reach the mineral soil layer, the same as in removing the organic materials originally.
Tools, equipment and the like for decontamination work		(per 10,000 m^2) Tools, equipment to use: Quantity Rakes or the like: - Large sandbags: -
Workforce needed		(per 10,000 m^2) Workforce needed: Quantity Operation leaders: 3.6 worker-days Decontamination workers: 24.0 worker-days
Idea development, lessons, points to keep in mind, etc.	Prerequisites and constraints regarding objects and locations to be decontaminated	● Exposed roots of trees and low areas on the slopes may induce surface water streams, causing deterioration of forests. Prior to commencing the work of removing organic materials, the forest manager and supervisory personnel shall be closely consulted on designating the area of work.
	Radiation exposure protection of workers	● Dust masks, rubber gloves and the like shall be worn. ● Precautions shall be taken to prevent inhaling fine organic materials scattered when the residue is being collected

	General labor safety of workers	● Safety measures shall be taken for the work with heavy machinery (proper arrangement for preventing minor collisions of adjacently working heavy machinery, and adequate instructions and supervision, as well as thorough control for preventing access to the machinery)
	Measures to prevent secondary wastes	−
	Others	−

(2) Coniferous evergreen trees

1) Pruning coniferous trees and collecting pruned branches

Locations to be decontaminated	"11.1.3. Trees" of "11.1. Coniferous evergreen trees" in "11. Forests"
Decontamination methods	Pruning coniferous trees and collecting pruned branches

Outline	Coniferous evergreen trees in the forests shall be pruned and the pruned branches shall be collected in the following procedure. (i) Pruning (ii) Collecting pruned branches
Decontamination processes	● Branches of living coniferous evergreen trees (cedar, Japanese cypress, and the like) of more than 3 year old class shall be cut off using saws or the like up to the height of about 4 m from the ground, if they stand within about 5 m from the forest edge (about 1 or 2 rows). But the tree canopies of more than half of their original size shall be left. If branches and leaves of living trees considerably hang above buildings, they shall be cut off using saws and the like. ● Branches too long to pack in large sandbags as they are shall be chopped into packable sizes, or cut into less than 2 m long pieces and tied using strings or the like in about 30 cm diameter bundles. The bundles shall be collected and piled up at the forest edge for subsequent processes (transfer to volume reduction facilities or volume reduction by wood crushers).
Tools, equipment and the like for decontamination work	(see table below)
Workforce needed	■ ■When cutting cedars, (per 10,000 m²) (see table below) *In cases pruned branches and fallen leaves are bundled and transferred to the bottom of slopes.

Tools, equipment and the like for decontamination work:

Tools, equipment to use	Quantity
Saws or the like	-
Large sandbags	-

Workforce needed — ■When cutting cedars, (per 10,000 m^2)

Workforce needed	Quantity
Operation leaders	16.1 worker-days
Decontamination workers (for pruning)	77.5 worker-days
Decontamination workers (for bundling)	29.7 worker-days

*In cases pruned branches and fallen leaves are bundled and transferred to the bottom of slopes.

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■ When cutting Japanese cypress,

(per 10,000 m^2)

Workforce needed	Quantity
Operation leaders	19.4 worker-days
Decontamination workers (for pruning)	99.3 worker-days
Decontamination workers (for bundling)	29.7 worker-days

*In cases pruned branches and fallen leaves are bundled and transferred to the bottom of slopes.

■ When cutting Japanese red pine and the like,

(per 10,000 m^2)

Workforce needed	Quantity
Operation leaders	16.9 worker-days
Decontamination workers (for pruning)	99.3 worker-days
Decontamination workers (for bundling)	13.2 worker-days

*In cases pruned branches and fallen leaves are bundled and transferred to the bottom of slopes.

</td></tr>
<tr><td rowspan="5">Idea development, lessons, points to keep in mind, etc.</td><td>Prerequisites and constraints regarding objects and locations to be decontaminated</td><td>● This method may be applied to windbreak trees around housing areas</td></tr>
<tr><td>Radiation exposure protection of workers</td><td>● Dust masks, rubber gloves and the like shall be worn.
● At the top of untreated trees, radioactive materials are likely to have attached. Maximum attention shall be paid not to touch materials falling from above (branches, leaves, dust, etc.)</td></tr>
<tr><td>General labor safety of workers</td><td>● Cautions shall be taken to prevent workers being hit with objects dropped during pruning.</td></tr>
<tr><td>Measures to prevent secondary wastes</td><td>–</td></tr>
<tr><td>Others</td><td>–</td></tr>
</table>

6.2. Verification of Decontamination Effects

Chapter 6.2 shows some of the verification results of decontamination effects in the decontamination works done under various test conditions in the Special Decontamination Areas as arranged by the MOE.

It should be noted that the decontamination effects depend on various environmental conditions such as material properties or surface conditions of the objects subject to decontamination, or their aging variation with time, and therefore, the same decontamination effects cannot be necessarily expected even if the same decontamination methods for a particular item are applied. There are also some cases which showed different results from those of model projects conducted by the Cabinet Office and Japan Atomic Energy Agency (JAEA) or those experienced in the first stage decontamination work in relatively high dose areas in Fukushima Prefecture (mainly in JFY 2011).

It should be also noted that the decontamination methods and application conditions cannot be decided solely by the test decontamination results. The specific decontamination methods and application conditions have been decided for individual communities upon the residents' consent with consideration to workability, preservation of functions of the item to be decontaminated, and the like.

The verification results are shown below for individual decontamination methods tested in two groups of Special Decontamination Areas, i.e., relatively low dose areas of residing-restricted areas (the areas in which residing is restricted) and the evacuation order lifting preparation areas (the areas in which the evacuation orders are being prepared for lifting), and relatively high dose areas of difficult-to-return areas (the areas where it is expected that the residents have difficulties in returning for a long time).

The decontamination effects are shown basically in terms of the changes in surface contamination densities (cpm). But for farmland, where penetrated contamination is likely, rather than surface contamination, the decontamination effects are expressed in terms of the change in dose equivalent (μSv/h).

6.2.1. Residing-restricted Areas (Areas in Which Residing is Restricted) or Evacuation Orders Lifting Preparation Areas (Areas in Which Evacuation Orders are Being Prepared for Lifting)

The following are the results of decontamination effects under various test conditions obtained from the decontamination work model projects authorized by the MOE in the residing-restricted areas and the evacuation order lifting preparation areas.

（1） Residential areas and the like

1）Roofs/rooftops

A) Wiping

- After removing sediment on roofs when present, one to three wiping operations were conducted using disposable paper wipes.
- The test decontamination was conducted on roofs facing east, south, west and north. Roofs facing east had mostly higher values of air dose rates and surface contamination densities than the other roofs. This will be attributed to the wind direction and the source of radioactive materials.
- Higher surface contamination densities (3,000 to 5,000 cpm) have been experienced on roofs with seams such as batten-seamed roofs and folded-plate roofs or metallic roofs with rust such as galvanized steel sheets, while lower densities have been experienced on roofs with flat surface materials or fewer seams. This indicates that radioactive materials tend to be attached and remained on roof surfaces with uneven configurations, while from flat surface roofs radioactive materials may be washed away by rainfall even if attached once.
- The air dose rate was reduced by about -13 to +28% (about 9 to 11% on the average) by wiping the roofs after removing sediment, and the surface contamination densities were reduced by about -13 to +79% (average about 27 to 39%).
- There were variations in the radiation reduction effects by wiping. Even 10 wiping operations did not lower the dose to the lowest level. Once the contamination is reduced to several hundred [cpm], the data variation becomes big. The radiation reduction effects at a particular place remained almost unchanged even if wiping operations were repeated (once, twice, three times and ten times).

Table 6-2 Example results in residential areas, etc. of wiping roofs and rooftops

Work Schedule	Air dose rate[139] at 1 cm away from the surface (μSv/h)	Surface contamination density (without shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
Before wiping	1.2	1.32×10^3	–	–
After first wiping	1.0	6.00×10^2	11	33
After second wiping	1.1	5.57×10^2	9	36
After third wiping	1.0	5.00×10^2	11	39
After tenth wiping	1.0	5.20×10^2	10	27

※ Dose equivalent rate, surface contamination density and reduction rate are the average of their measurements.

※ Even if the reduction rate was negative at a measuring point, the reduction rate of the concerned point was not considered to be zero, and was calculated using the raw value (negative value).

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method

2) Exterior walls/outside walls

A) Wiping, brushing

- Glass surfaces, siding walls, wooden walls, mortar walls, earthen walls, and galvanized steel sheet walls, corrugated sheet walls and metal walls were wiped or brushed once to three times (both for mortar walls, but only brushing for earthen walls and only wiping for others).
- Whatever the material was, the surface contamination densities were confirmed to be lower than those on the roofs or in the rainwater gutters.
- The dose rate was basically low, and the dose rate change was minimal even when wiped or brushed, irrespective of moss presence, the wall materials, and the numbers of wiping and brushing operations.

3) Rainwater gutters

A) Sediment removal, wiping

- Sediment causes high dose rates. There is a case in which the maximum dose rate before decontamination was 10 μSv/h and the surface contamination density was 17,000 cpm.
- The reduction effects by removing sediment was about 3 to 78% (average 42%) for air dose rates and about 20 to 59% (average 35%) for surface contamination densities. The effects by wiping were about –11 to +18% (average about 7 to 11%) for air dose rates and about –30 to +52% (average about –1 to +11%) for surface contamination densities.
- In decontaminating rainwater gutters, sediment removal is most effective. This is because the sediment includes most of the radioactive contaminants.

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139 Air dose rate measured 1 cm away from the ground or 1 cm away from the surface of target.

Table 6-3 Example results in residential areas, etc. of removing sediment from rainwater gutters followed by wiping

Work Schedule	Air dose rate at 1 cm away from surface (μSv/h)	Surface contamination density (without shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%)	Decontamination rate of Surface contamination density (%)
Before removing sediments	5.2	1.03×10^{4}	—	—
After removing sediments	2.0	5.87×10^{3}	42	35
After first wiping	1.9	6.07×10^{3}	7	(-1)
After second wiping	1.8	5.27×10^{3}	9	11
After third wiping	1.8	5.27×10^{3}	11	6

※ The effect of decontamination depends on the various factor such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

4）Street drains

A) Sediment removal

- In street drains the maximum air dose rate of 2.4 μSv/h and surface contamination density of 1,310 cpm were observed before decontamination.
- The reduction in the surface contamination density reached as high as 47%. The concrete covers of street drains lowered the surface contamination density to as low as 290 cpm.

Table 6-4 Example results in residential areas, etc. of removing sediment from side ditches

Work Schedule	Air dose rate at 1 cm away from surface (μSv/h)	Surface contamination density (without shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%)	Decontamination rate of surface contamination density (%)
With cover (before work)	1.4	4.10×10^2	–	–
Without cover (before work)	2.4	1.31×10^3	–	–
After removing sediments	1.4	6.90×10^2	42	47
After cleaning side ditches	1.4	5.10×10^2	42	61
With cover (after work)	1.1	2.90×10^2	54	78

※ The reducing rate is the value after the cover was removed.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and etc.The results shown above are the results which have been examined for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by using the same decontamination method.

5）Outdoor equipment and the like

A) Wiping

- Wiping operation was done one to three times.
- The maximum air dose rate and surface contamination density of outdoor equipment and the like have been measured as 0.80 μSv/h and 920 cpm, respectively.
- The reduction rate of air dose rates was about -6 to +6% on the average and that of surface contamination densities was about 44 to 85% on the average.
- By repeating the wiping operation, the surface contamination densities decreased

Table 6-5 Example results in residential areas, etc. by wiping outdoor equipment and the like

Work Schedule	Air dose rate at 1 cm away from surface (μSv/h)	Surface contamination density (without shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%)	Decontamination rate of surface contamination density (%)
Before wiping	8.0×10^{-1}	9.20×10^{2}	—	—
After first wiping	8.5×10^{-1}	5.20×10^{2}	(-6)	44
After second wiping	7.5×10^{-1}	2.10×10^{2}	6	77
After third wiping	7.5×10^{-1}	1.40×10^{2}	6	85

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

（2） **Schools**

1）**Roofs of a swimming pool**

A) **Wiping**

- The top part and the lower part of the roofs of a swimming pool were wiped.
- The surface contamination density at the top was 340 to 440 cpm (average 400 cpm) before decontamination. At the lower part it was 560 to 630 cpm (average 600 cpm). The surface contamination density at the lower part was slightly higher than that at the top.
- The reduction rate of air dose rates by wiping was –4 to +4% on the average, while that of surface contamination densities was about 27% to 36% on the average.

Table 6-6 Example results in schools of wiping swimming pool roofs

Work Schedule		Air dose rate at 1 cm away from surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%)	Decontamination rate of surface contamination density (%)
Upper	Before wiping	1.2	4.00×10^2	–	–
	After wiping	1.2	2.60×10^2	4	36
Lower	Before wiping	1.8	6.00×10^2	–	–
	After wiping	1.9	4.30×10^2	(-4)	27

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore、it does not assure that the equivalent effect can be attained by the same decontamination method.

2）**Pool sides**

A) **High-pressure water cleaning**

- High-pressure cleaning (vacuum collection 15 MPa, discharge flow rate of 12.7 L/min and 20 L/m^2) were done one to three times.
- The surface contamination density was 6,550 to 11,000 cpm, and the average was 9,330 cpm before decontamination. The pool side surface material was rubbery and black dirt was recognized on the surface and roughness was locally observed in the area to be decontaminated.
- After the first high pressure cleaning, unevenness of the cleaning was visually observed on the pool side surfaces. After the second high pressure cleaning, hardly any cleaning unevenness was visible on the surface. After the third high pressure cleaning, it was visually confirmed that the dirt was almost uniformly removed from the surface.
- As a result of implementing high-pressure water cleaning, the rate of reduction in the air dose rate was approximately 76 to 79% on average, and the percent decrease in surface contamination density was approximately 93 to 98% on average.

Table 6-7 Example results in schools for high-pressure water cleaning of swimming pool sides

Work Schedule	Air dose rate at 1 cm away from surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%)	Decontamination rate of surface contamination density (%)
Before high pressure cleaning	3.4	9.33×10^{3}	–	–
After first cleaning	8.1×10^{-1}	6.50×10^{2}	76	93
After second cleaning	6.9×10^{-1}	2.70×10^{2}	79	97
After third cleaning	7.0×10^{-1}	1.90×10^{2}	79	98

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

3) **Exterior walls (with minor staining)**

A) **Brushing (dry)**

- The decontamination effect by brushing in dry conditions was checked on the test target portion of the exterior wall surface with minor staining.
- When shielding was used for more reliable measurement, the surface contamination density was 100 to 110 cpm and the average was 100 cpm before decontamination.
- The surface contamination density after dry brushing was 90 to 150 cpm and the average was 130 cpm.
- Little change was observed, since the contamination before decontamination was low enough.

Table 6-8 Example results of (dry) brushing school external walls (with minor staining)

Work Schedule	Air dose rate at 1 cm away from surface (μSv/h)	Surface contamination density (without shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%)	Decontamination rate of surface contamination density (%)
Before brushing	9.1×10^{-1}	1.00×10^{2}	—	—
After brushing	8.6×10^{-1}	1.30×10^{2}	6	(-24)

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore、it does not assure that the equivalent effect can be attained by the same decontamination method.

4) **Exterior Wall (with major staining)**

A) **Brushing (wet)**

- The decontamination effect by one-time brushing or twice brushing in wet conditions was checked on the test target portion of the exterior wall surface with major staining.
- When shielding was used for more reliable measurement, the surface contamination density was 310 to 620 cpm and the average was 430 cpm before decontamination.
- The surface contamination density after the first brushing was 180 to 430 cpm and the average was 280 cpm. The surface contamination rate after the second brushing was 230 to 420 cpm and the average was 320 cpm, slightly higher than those after the first brushing. It was interpreted that uncertainties were included in the data due to low contamination. Because of the low values before decontamination for the wall, the average reduction rate in the second brushing was 24 %.

Table 6-9 Example results of (wet) brushing school external walls (major staining)

Work Schedule	Air dose rate at 1 cm away from surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%)	Decontamination rate of surface contamination density (%)
Before brushing	1.2	4.30×10^2	−	−
After first brushing	1.1	2.80×10^2	6	35
After second brushing	1.2	3.20×10^2	(-5)	24

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and etc.The results shown above are the results which have been examined for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by using the same decontamination method.

5）Slopes in School Playground

A) Weeding and lawn scraping

- Slopes in a school playground were weeded and the lawns were scraped away.
- The surface contamination density was 1,490 to 1,970 cpm, and the average was 1,580 cpm before decontamination.
- The surface contamination density was 1,920 to 2,710 cpm and the average was 2,380 cpm after weeding, higher than that before weeding. After scraping lawns away by a backhoe, the surface contamination density dropped to 170 to 280 cpm and the average to 230 cpm. (The average reduction rate of surface contamination densities was about 85%).

Table 6-10 Example results of implementing weeding and lawn scraping on slopes in a school playground

Work Schedule	Air dose rate at 1 cm away from surface (μSv/h)	Air dose rate at 1 m away from surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%))	Decontamination rate of Air dose rate at 1 m away from surface (%)	Decontamination rate of surface contamination density (%)
Before weeding	4.8	3.2	1.58×10^3	−	−	−
After weeding	4.5	2.8	2.38×10^3	6	12	(-53)
After scrapping lawn	1.4	2.1	2.30×10^2	72	35	85

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

6）Pavement (berm[140] concrete)

A) Abrasive vacuum blasting

- The abrasive vacuum blasting effect for berm concrete was checked. The blasting speed was set at 4 min/m^2.
- Berm concrete surfaces are often found under the eaves at schools or large size facilities. Hot spots were frequently generated there caused by rain dripping from roofs.
- The reduction rate of surface contamination densities by abrasive vacuum blasting was about 81% on the average.

[140] Berm concrete is an earthen-based concrete surface often found on the ground under eaves in order to prevent water intrusion into buildings.

Table 6-11 Example results of implementing abrasive vacuum blasting of pavement surfaces (berm concrete) in schools

Work Schedule	Air dose rate at 1 cm away from surface (μSv/h)	Air dose rate at 1 m away from surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%))	Decontamination rate of Air dose rate at 1 m away from surface (%)	Decontamination rate of surface contamination density (%)
Before blasting	—	—	2.00×10^{3}	—	—	—
After blasting	—	—	3.80×10^{2}	—	—	81

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

(3) Roads

1) Paved surfaces

A) **High-pressure water cleaning**.

- Test cleaning was executed on a paved road at three different flow rates of 10 L/m^2, 15 L/m^2 and 20 L/m^2. The discharge pressure of high pressure water cleaning was set at 15 MPa.
- The dose rates before decontamination were 1.0 to 1.1 μSv/h at 1 cm from the surface and 1.1 to 1.2 μSv/h at 1m above the ground, and the surface contamination density was 310 to 530 cpm.
- The reduction rates of doses rate in all cases were 26 to 29% at 1cm from the surface and 9 to 11% at 1m above ground, and those of surface contamination densities were 55 to 66%. The decontamination effect was evident. Concerning the effect of cleaning water flow rates, no significant difference was observed.

Table 6-12 Example results of implementing high-pressure water cleaning of road pavement surfaces

Water flow rate		Air dose rate at 1 cm away from surface (μSv/h)	Air dose rate at 1 m away from surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%))	Decontamination rate of Air dose rate at 1 m away from surface (%)	Decontamination rate of surface contamination density (%)
10L/m^2	Before cleaning	1.1	1.1	1.18×10^3	–	–	–
	After cleaning	7.8×10^{-1}	1.0	5.30×10^2	29	11	55
15L/m^2	Before cleaning	1.0	1.1	9.90×10^2	–	–	–
	After cleaning	7.2×10^{-1}	9.8×10^{-1}	4.50×10^2	29	9	55
20L/m^2	Before cleaning	1.0	1.2	9.10×10^2	–	–	–
	After cleaning	7.4×10^{-1}	1.0	3.10×10^2	26	11	66

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

2） **Street drains**

A) **High-pressure cleaning**

- Decontamination effects of the air dose rate and surface contamination density were measured at the two removable grating covers.
- The reduction rates were about 64% for both of dose rates (at 1 cm from the surface) and surface contamination densities, while the reduction rate for the dose rates at 1 m above the ground was about 14%.

Table 6-13 Example results of implementing high-pressure water cleaning of road side ditches

Work Schedule	Air dose rate at 1 cm away from the surface (μSv/h)	Air dose rate at 1 m away from the surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%))	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
Before cleaning(※)	1.7	1.0	5.30×10^{2}	―	―	―
After cleaning(※)	6.1×10^{-1}	9.0×10^{-1}	1.90×10^{2}	64	14	64

※ The measurement which was measured using a collimator.at one location.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

（4） **Farmland**

1） **Rice fields**

A) **Leveling unevenness**

- The uneven topsoil was leveled by using a vibratory roller (combined roller). After leveling the unevenness, irregularity of the test area was checked for the measurements.
- The maximum difference in elevation of unevenness in rice fields was 40 to 60 mm before leveling. In areas with many wild boars, it was confirmed that the difference had increased to 95 to 110 mm.
- It could be seen that the unevenness was reduced to 20 to 43 mm by leveling and the ground surface looked generally smooth. In the rice fields of areas with many wild boars, the unevenness was 57 to 97mm after leveling. It was visually confirmed that leveling by vibratory rollers could reduce the unevenness. The big unevenness caused by wild boars could have been certainly reduced, but the change was minimal.
- If the surface soil hardness was more than approximately 10 mm (by Yamanaka' durometer), leveling work was possible. If there were many consecutive rainy days, the soil hardness was less than 10 mm, and the leveling work was hard to do. The access conditions (the access route, road widths or other conditions) of heavy machinery should be checked in advance. Only roads with the gradient of 20 degrees or less were accessible by heavy machinery.

2) Dry fields

A) Off-scraping of topsoil

- Topsoil was scraped off, after spraying surface solidifiers, by soil skimmers[141].
- The reduction rate of dose rates at 1 cm from the surface and at 1 m above the ground was about 36 to 37% and the reduction rate of surface contamination densities was about 47%.
- The amount of soil carried out from dry fields by skimmers was 41 flexible container bags, weighing 37.2 tons. When the area of 400 m^2 was scraped uniformly to the depth of 5 cm, the theoretical amount should have been 30 tons (specific gravity: 1.5). Actually, 7.2 tons (about 24%) more topsoil was scraped off than the planned amount.
- Skimmers with rubber caterpillars could run smoothly for scraping. The surface finish after scrapping topsoil was also good. The topsoil scraping approach by skimmers is appropriate for application in large flat fields.

Table 6-14 Example results of scraping topsoil in fields

Work Schedule	Air dose rate at 1 cm away from surface (μSv/h)	Air dose rate at 1 m away from surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from surface (%))	Decontamination rate of Air dose rate at 1 m away from surface (%)	Decontamination rate of surface contamination density (%)
Before scrapping	2.1	2.4	5.70×10^2	–	–	–
After scrapping	1.3	1.5	2.70×10^2	37	36	47

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

[141] Topsoil scrapping and recovering machine

(5) **Forests**

A) **Surface layer removal and topsoil scraping**

- The air dose rate was measured before weeding and surface layer (dry leaves) removal. After weeding and removing dry leaves, the level obtained was defined as the reference level (DL-0cm). The dose rate and the surface contamination density were measured at 1cm intervals in the depth direction from the reference level. The measurement was terminated when hard soil layers appeared at the depth of DL-3cm to DL-4cm.
- Measurements were implemented at three locations; on the southern slope of a forest of deciduous trees, on the southern slope of a forest of evergreen trees, and on the western slope of a forest of deciduous trees.
- Occasionally the dose rate increased by weeding and dry leaf removal. The surface contamination density decreased by removing the surface topsoil as seem in the measurements made at 1cm intervals. By removing the surface topsoil by about DL-2 to DL-3cm from the reference level, the surface contamination density decreased to about 200 to 950 cpm. The reduction rate of surface contamination densities reached about 25 to 63% (about 36 to 53% on the average). The higher the initial surface contamination density was, the higher the reduction rate was achieved.
- It was understood that removing surface soil as deep as DL-2 to -3cm was appropriate for the site conditions and the viewpoints of radiation reduction and soil erosion.

Table 6-15 Example results in a forest for surface layer removal and topsoil scraping

Work Schedule	Air dose rate at 1 cm away from the surface (μSv/h)	Air dose rate at 1 m away from the surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
Before removing surface layer	2.5	2.3	9.2×10^2	–	–	–
After removing surface layer	2.5	2.0	9.7×10^2	(-1)	10	(-2)
DL-1 cm	2.4	2.0	9.9×10^2	5	12	(-5)
DL-2 cm	1.9	2.0	6.1×10^2	25	12	36
DL-3 cm	1.5	1.9	4.4×10^2	39	14	53
DL-4 cm(※)	1.8	2.9	4.0×10^2	53	26	68

※ DL-4cm was measured at one location.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which habe been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

6.2.2. Difficult-to-return Area (Areas Where It Is Expected That the Residents Have Difficulties in Returning for a Long Time)

The following are the results of decontamination effects under various test conditions obtained from the decontamination work model projects authorized by the MOE in the difficult-to-return area.

The surface contamination densities were always measured in terms of the radiation dose at 1cm from the surface. Beta rays from the surface contamination were measured as the difference between the values with a collimator and the acrylic shielding plate and with only a collimator.

（1） **Residential areas and the like**

1）**Roofs**

A) **Wiping**

- Test decontamination was executed for two types of roofing materials (ceramic tiles and galvanized steel sheets) in District A and only ceramic tiles in District B.
- In District A, the surface contamination densities showed big variation in data, probably due to different surface configurations. The decontamination effect was evaluated in terms of the dose equivalent rate.
- The reduction rate of air dose rates (at 1cm from the surface, with a collimator) in District A was 0 to 12%, showing no visible decontamination effects. Such results were also found at other test cases. Significant reduction effects could not be confirmed even for different wiping methods.
- In District B, no significant reduction effects could be confirmed in evaluating the air dose rates (at 1cm, with a collimator). On the other hand, in the evaluation of surface contamination densities, some reduction effects could be confirmed by the first wiping, but no further effects were confirmed by further wiping.
- Wiping by disposable paper towels was chosen as the standard method, by which improvement in decontamination workability could be expected.
- In consideration of workability, wiping more than once, and finishing work by the second wiping operation was chosen as the standard decontamination method for roofs.

Table 6-16 Example results of wiping roofs on residential land, etc. (District A residences, ceramic tiles)

Work Schedule		Air dose rate at 1 cm away from the surface (μSv/h)	Surface contamination density (without shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
Dry paper towel	Before wiping	7.7×10^{-1}	–	–	–
	After wiping	7.8×10^{-1}	–	(-2)	–
Wet paper towel	Before wiping	7.5×10^{-1}	–	–	–
	After wiping	7.7×10^{-1}	–	(-3)	–

※ The value shown in the table is the average of the value (s) measured at 3 locations.
※ The decontamination rate is the average value of decontamination rate at each measurement point.
※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

Table 6-17 Example results of wiping roofs on residential land, etc. (District A residences, galvanized steel sheet plate roofs)

Work Schedule		Air dose rate at 1 cm away from the surface (μSv/h)	Surface contamination density (without shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
Dry paper towels	Before wiping	1.1	–	–	–
	After wiping	1.1	–	6	–
Wet paper towels	Before wiping	1.2	–	–	–
	After wiping	1.1	–	7	–

※ The value shown in the table is the average of the value (s) measured at 3 locations.
※ The decontamination rate is the average value of decontamination rate measured at each point.
※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been executed in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

Table 6-18 Example results of wiping roofs on residential land, etc. (District B, ceramic tiles)

Work Schedule	Air dose rate at 1 cm away from the surface (μSv/h)	Surface contamination density (without shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
Before wiping	1.1	1.41×10^3	–	–
After first wiping	1.2	1.25×10^3	(-3)	11
After second wiping	1.1	1.23×10^3	4	12
After third wiping	1.1	1.20×10^3	2	15

※ The value shown in the table is the average of the value (s) measured at 5 locations.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

B) **Brushing**

- Test decontamination of cement tile roofs in District A was conducted by using a deck brush.
- Generally decontamination is believed to be ineffective on cement tiles.
- The decontamination effect was checked by two ways of brushing, in one direction or back-and-forth directions ten times. However, it was confirmed that the reduction rate of surface contamination densities was 0%, showing no decontamination effects.
- The poor decontamination effect was understood to be due to rough surfaces of cement tiles, on which fine grains containing radioactive materials were easily deposited into the porous structure of the surface layer.
- It was found that brushing had no decontamination effects at all.

Table 6-19 Example results of brushing cement tile roofs on residential land, etc.

Work Schedule		Air dose rate at 1 cm away from the surface (μSv/h)	Surface contamination density (without shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
One way brushing	Before wiping	–	1.12×10^4	–	–
	After two times wiping	–	1.12×10^4	0	–
	After four times wiping	–	1.12×10^4	0	–
Round brushing	Before wiping	–	1.00×10^4	–	–
	After ten times wiping	–	1.00×10^4	0	–

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

2) **Exterior Walls**

A) **Wiping**

- For exterior walls, wiping effects were tested on the wall materials such as soft lysine-sprayed walls, pea gravel-washed walls and metallic siding. In many cases the decontamination effect had little correlation with the wall materials.
- Although no big difference was recognized depending on different wiping methods, wiping by wet paper towels was chosen as the standard decontamination method for external walls, in consideration of the test results on the roofs and workability.
- The decontamination rate of the third wiping from the second wiping was -1% in District C and +12% in District D. The improvement of decontamination in the third wiping was not significant when compared with those of the first two wiping steps.
- For the exterior wall decontamination, twice wiping (finishing work by the second wiping) was chosen as the standard decontamination method.

Table 6-20 Example results of wiping external walls on residential land, etc.

Work Schedule		Air dose rate at 1 cm away from the surface (with shielding, μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
Ceramic siding, wiping by dry paper towel	Before wiping	–	7.84×10^2	–	–
	After first wiping	–	6.43×10^2	–	18
	After second wiping	–	5.52×10^2	–	30
	After third wiping		5.60×10^2		29
Metallic siding, [wiping by wet paper towel	Before wiping	2.2	–	–	–
	After first wiping	1.8	–	18	–
	After second wiping	1.7	–	25	
	After third wiping	1.5		35	

※ For metallic siding, many discrepancies due to impact to be considered that surface shape affected on surface contamination density were confirmed. Therefore, the effect was evaluated by dose equivalent rate.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

3) **Gutters**

A) Sediment removal and wiping

- Test decontamination of gutters were done by wiping, the standard method, changing the number of wiping operations under two conditions of wet wiping and dry wiping.
- Collimators could not be used for the air dose rate measurements due to narrow gutter openings.
- For the surface contamination density, the first wiping after removing sediment gave a high decontamination rate. No further big decrease could be observed even if wiping was repeated. Wet wiping gave a higher decontamination rate than dry wiping.
- A combination of wiping by wet paper towels and wiping once or more after removing sediment was chosen as the standard decontamination method for gutters.

Table 6-21 Example results in residential areas of removing sediment from roof gutters followed by wiping

Work Schedule		Air dose rate at 1 cm away from the surface (with shielding, μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
Dry wiping (wiping by dry paper towel)	Before wiping	3.0×10	–	–	–
	After removing sediments	1.2×10	2.25×10^4	61	–
	After first wiping	9.2	2.31×10^4	69	(-3)
	After second wiping	8.7	1.74×10^4	71	23
	After third wiping	9.0	1.26×10^4	70	44
	After fourth wiping	8.9	1.55×10^4	70	31
	After fifth wiping	8.8	1.35×10^4	71	40
	After sixth wiping	8.8	1.35×10^4	71	40
Wet wiping (wiping by wet paper towel)	Before wiping	3.0×10	–	–	–
	After removing sediments	1.2×10	2.25×10^4	61	–
	After first wiping	1.0×10	9.75×10^3	66	56
	After second wiping	1.0×10	7.30×10^3	66	67
	After third wiping	1.0×10	5.60×10^3	66	74
	After fourth wiping	1.0×10	7.20×10^3	66	67
	After fifth wiping	1.0×10	7.00×10^3	66	68
	After sixth wiping.	1.0×10	7.00×10^3	66	68

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

4) **Paved surfaces**

A) **High-pressure water cleaning and shot-blasting**

- Test decontamination of paved surfaces were executed by the following three methods; i) high-pressure water cleaning with vacuum collection of water (water pressure of 20 MPa, 2 times cleaning), ii) shot-blasting (discharge pressure of steel shot, 5M Pa by the standard decontamination method in accordance with the decontamination guidelines) and iii) shot-blasting (discharge pressure of steel shot, 7M Pa). The decontamination rates were compared, the damaged condition of paved surfaces was checked and the applicable scope of each decontamination method was verified.
- The highest decontamination rate was obtained by the standard method of shot-blasting (discharge pressure of steel shot 7 MPa), but shot-blasting marks remained on the paved surface and the road surface markings were even erased.
- The high-pressure water cleaning with vacuum collection of water was appropriate to apply in narrow gaps and on the paved surfaces where damage should be avoided. The shot-blasting at 7 MPa could basically be applied to flat places over a certain distance for continuous working. The lines on the roads and the locations vulnerable to damage should be blasted at 5 MPa.

Table 6-22 Example results in residential areas, etc. of implementing high-pressure water cleaning and shot-blasting of pavement surface (Asphalt pavement)

Work Schedule		Air dose rate at 1 cm away from the surface (μSv/h)	Air dose rate at 1 m away from the surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%))	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
Suction type high pressure water	Before cleaning	–	–	7.51×10^3	–	–	–
	After cleaning	–	–	3.45×10^3	–	–	53
Shot blasting 5mpa	Before blasting	–	–	6.16×10^3	–	–	–
	After blasting	–	–	3.89×10^3	–	–	37
Shot blasting 7mpa	Before blasting	–	–	8.08×10^3	–	–	–
	After blasting	–	–	1.25×10^3	–	–	84

※ The value shown in the table is the average of the value (s) measured at 5 locations.
※ The decontamination rate is the average value of decontamination rate at each measurement point.
※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

Table 6-23 Example results in residential areas, etc. of implementing high-pressure water cleaning and shot-blasting of pavement surface (Concrete pavement)

Work Schedule		Air dose rate at 1 cm away from the surface (μSv/h)	Air dose rate at 1 m away from the surface (μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%))	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
Suction type high pressure water	Before cleaning	－	－	2.45×10^4	－	－	－
	After cleaning	－	－	1.06×10^4	－	－	56
Shot blasting 7 MPa	Before blasting	－	－	2.08×10^4	－	－	－
	After blasting	－	－	7.92×10^3	－	－	63

※ The value shown in the table is the average of the value (s) measured at 5 locations.

※ The decontamination rate is the average value of decontamination rate at each measurement point.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

（2） **Schools**

1） **Rooftops**

A) **High-pressure water cleaning**.

- Test decontamination was conducted on the rooftop of a kindergarten building covered by water proof sheets using high-pressure water cleaning with vacuum water collection. The discharge flow rate of 20 Lm^3/m^2 was used at two water pressure conditions of 10 MPa and 15 MPa in the test.
- No big difference in decontamination rates was observed for the two pressure conditions, 10 MPa and 15 MPa. No further significant decrease of decontamination rates was found by the second and further cleaning, regardless of the cleaning pressure.
- The standard cleaning method for rooftops was set as “one time cleaning at 15MPa.

Table 6-24 Example results of implementing high-pressure water cleaning of school roofs

Work Schedule		Air dose rate at 1 cm away from the surface (with shielding μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
Cleaning water pressure (10mpa)	Before cleaning	−	3.12×10^2	−	−
	After first cleaning	−	5.80×10	−	81
	After second cleaning	−	3.40×10	−	89
	After third cleaning	−	9.00×10	−	71
Cleaning water pressure (15mpa)	Before cleaning	−	3.90×10^2	−	−
	After first cleaning	−	7.80×10	−	80
	After second cleaning	−	7.80×10	−	80
	After third cleaning	−	5.80×10	−	85

※ The value shown in the table is the average of the value (s) measured at 5 locations.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

（3） **Parks**

1）**Playgrounds and the like**

A) **Scraping topsoil and earth covering**

- Topsoil in a playground in a kindergarten facility was scraped and the scraped surface was covered afterward with fresh soil. Two scraping depths of 5 cm and 10 cm were used.
- It was found that even 5 cm scraping could obtain a decontamination rate of more than 90%.
- The standard decontamination method for parks (playgrounds) was set as scrapping topsoil by 5 cm and earth covering by 5 cm.

Table 6-25 Example results of scraping topsoil followed by earth covering on park playgrounds, etc.

Work schedule		Air dose rate at 1 cm away from the surface (with shielding ,μSv/h)	Air dose rate at 1 m away from the surface (with shielding μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%))	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
Scraping depth (5cm)	Before scraping	–	–	8.76×10^2	–	–	–
	After scraping	–	–	4.00×10	–	–	95
	After covering	–	–	2.80×10	–	–	97
Scraping depth (10cm)	Before scraping	–	–	1.10×10^3	–	–	–
	After scraping	–	–	1.40×10	–	–	99
	After covering	–	–	3.40×10	–	–	97

※ The value shown in the table is the average of the value (s) measured at 5 locations.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

(4) **Large size facilities**

1) **Rooftops**

A) **High-pressure water cleaning**

- The standard method of high-pressure water cleaning was tested for the rooftop of a hospital covered by waterproof sheets and cinder concrete. The discharge flow rate of 20 Lm^3/m^2 was used at two water pressure conditions of 10 MPa and 15 MPa in the test.
- Higher decontamination rates were obtained by 15 MPa cleaning than 10 MPa cleaning.
- For the waterproof sheet rooftops, the decontamination rate of 3% was obtained by the second cleaning. Therefore, the most effective decontamination method was twice cleaning at 15MPa water pressure. For the cinder concrete rooftops, no significant decontamination rate could be observed regardless of the number of cleaning times and water pressure.
- The standard decontamination method was set as one-time cleaning at 15MPa water pressure for both types of rooftops of large size facilities, in due consideration of workability and overlapping of work areas.

Table 6-26 Example results of implementing high-pressure water cleaning of roofs on large-size facilities (waterproof sheeting)

Work Schedule		Air dose rate at 1 cm away from the surface (with shielding μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
Cleaning water pressure (10mpa)	Before cleaning	－	2.98×10^2	－	－
	After first cleaning	－	1.48×10^2	－	50
	After second cleaning	－	1.34×10^2	－	55
Cleaning water pressure (15mpa)	Before cleaning	－	2.04×10^2	－	－
	After first cleaning	－	1.10×10^2	－	46
	After second cleaning	－	6.80×10	－	67
	After third cleaning	－	6.20×10	－	70

※ The value shown in the table is the average of the value (s) measured at 5 locations.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

Table 6-27 Example results of implementing high-pressure water cleaning of roofs on large-size facilities (cinder concrete)

Work Schedule		Air dose rate at 1 cm away from the surface (with shielding μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Surface contamination density (%)
Cleaning water pressure (10mpa)	Before cleaning	–	5.77×10^3	–	–
	After first cleaning	–	2.54×10^3	–	56
	After second cleaning	–	2.33×10^3	–	60
Cleaning water pressure (15mpa)	Before cleaning	–	6.50×10^3	–	–
	After first cleaning	–	2.32×10^3	–	64
	After second cleaning	–	1.98×10^3	–	70

※ The value shown in the table is the average of the value (s) measured at 5 locations.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

2) Paved surfaces

A) Shot-blasting

- The shot-blasting for paved surfaces in a hospital premise was tested with different discharge pressures of steel shot, 7 MPa (the standard decontamination method) and 5 MPa. The low discharge pressure was tested in order to consider preventing the paved surface from being damaged. The decontamination effect was also tested on the asphalt surface and road surface markings (drawn by the thermoplastic method). Decontamination rates and the degree of damage were compared between decontamination methods.
- The highest decontamination rate was obtained by the standard decontamination method of shot-blasting (7 MPa discharge pressure of steel shot). But marks due to steel shot remained on the paved surfaces and the white surface marking were erased.
- It is necessary to lower the discharge pressure to about 5 MPa or to consider an alternative method for places with road surface markings.

Table 6-28 Example results of implementing shot-blasting on pavement surface (conventional pavement surface) of large-size facilities

Work schedule		Air dose rate at 1 cm away from the surface (with shielding ,μSv/h)	Air dose rate at 1 m away from the surface (with shielding μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%))	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
7MPa with lap	Before blasting	–	–	5.86×10^{3}	–	–	–
	After blasting	–	–	5.02×10^{2} ※1	–	–	91 ※1
7MPa without lap	Before blasting	–	–	5.86×10^{3} ※2	–	–	–
	After blasting	–	–	6.15×10^{2} ※3	–	–	90 ※3

※1 The average of the values of measured at 5 locations

※2 Since the value before decontamination was not consistent with the value after decontamination, it was compared using the average of measurements in a decontamination targets.

※3 The average of the values of measured at 4 locations.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

Table 6-29 Example results of implementing shot-blasting on pavement surface (white surface markings) of large-size facilities

Work schedule		Air dose rate at 1 cm away from the surface (with shielding ,μSv/h)	Air dose rate at 1 m away from the surface (with shielding μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%))	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
5MPa without lap	Before blasting	—	—	7.83×10^{3} ※1	—	—	—
	After blasting	—	—	4.50×10^{3} ※1	—	—	43 ※1
7MPa without lap	Before blasting	—	—	2.68×10^{3} ※2	—	—	—
	After blasting	—	—	3.83×10^{2} ※2	—	—	84 ※2

※1 The measurement were implemented at 3 locations. But, these data was abandoned, due to widely discrepancies.

※2 The average of 3 measurements. The decontamination rate is the average of the decontamination rate which was calculated in every location.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

3) Wood decks

A) Wiping, high-pressure water cleaning and superhigh-pressure water cleaning

- Wood decks of large facilities were decontaminated by wiping, high-pressure water cleaning and superhigh-pressure cleaning for tests.
- The decontamination rate by wiping with wet cleaning cloths was about 10%. Both the decontamination rates by superhigh-pressure water cleaning and high-pressure water cleaning were about 95%.
- The superhigh-pressure water cleaning caused splinters on the wood deck surfaces due to the high water pressure. Therefore, the high-pressure water cleaning was chosen as the standard decontamination method for wood decks.

Table 6-30 Example results of implementing high-pressure water cleaning and superhigh-pressure water cleaning of wood decks of large-size facilities

Work schedule		Air dose rate at 1 cm away from the surface (with shielding, ,μSv/h)	Air dose rate at 1 m away from the surface (with shielding, μSv/h)	Surface contamination density (with shielding, cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%)	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
Wiping by wet rag	Before wiping	–	–	3.89×10^3	–	–	–
	After wiping	–	–	3.29×10^3	–	–	15
High pressure 15 mpa	Before cleaning	–	–	8.99×10^3	–	–	–
	After cleaning	–	–	4.32×10^2	–	–	95
Superhigh pressure 70mpa	Before cleaning	–	–	7.70×10^3	–	–	–
	After cleaning	–	–	4.32×10^2	–	–	94

※ The value shown in the table is the average of the value (s) measured at 5 locations.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

(4) Roads

1) Paved surfaces

A) Superhigh-pressure water cleaning

- Decontamination by the superhigh-pressure water at the standard water pressure of 150 MPa may damage the road surface and erase road surface markings on it (center lines, outer lines), just as occurred by the shot-blasting. To set the appropriate cleaning pressure, test decontamination was conducted by changing the water pressures as 15, 30, 50, 100 and 150 MPa, while observing damage conditions of the road surface and the decontamination effect.
- The standard pressure for superhigh-pressure water cleaning is 150 MPa. The working pressure of 100 MPa does not show significant deterioration of decontamination rates.
- Concerning the damage on the surface, no big damage was observed below 30 MPa. But at 50 MPa, loosened materials were blown out and above 100 MPa, the lines (center lines and outer lines) were erased.
- It is necessary to consider lowering the water pressure below 100 MPa when working on road marking areas and portions where noticeable damage was found on the pavement.

Table 6-31 Example results of implementing superhigh-pressure water cleaning of road pavement surfaces

cleaning water pressure of superhigh pressure water cleaning		Air dose rate at 1 cm away from the surface (with shielding ,μSv/h)	Air dose rate at 1 m away from the surface (with shielding μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%))	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
15 MPa	Before cleaning	–	–	4.09×10^{3}	–	–	–
	After cleaning	–	–	1.99×10^{3}	–	–	51
30 MPa	Before cleaning	–	–	5.11×10^{3}	–	–	–
	After cleaning	–	–	2.08×10^{3}	–	–	60
50 MPa	Before cleaning	–	–	4.32×10^{3}	–	–	–
	After cleaning	–	–	1.21×10^{3}	–	–	72
100 MPa	Before cleaning	–	–	4.58×10^{3}	–	–	–
	After cleaning	–	–	7.20×10^{2}	–	–	83
150 MPa	Before cleaning	–	–	3.10×10^{3}	–	–	–
	After cleaning	–	–	6.30×10^{2}	–	–	80

※ The value shown in the table is the average of the value (s) measured at 3 locations.
※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

(5) **Farmland**

1) **Rice fields**

A) Scraping topsoil, covering by fresh soil, leveling of unevenness and double plowing

- Topsoil of rice fields in relatively high dose areas in the target area was scraped off by soil skimmers[142], and plowed after being covered by fresh soil. Prior to the scraping, the field was mowed, the cut materials were removed, the top soil was scraped and the unevenness was leveled by rolling compaction followed by double plowing to a depth of 3 cm.
- According to present knowledge, the radiocesium concentration in the layer below 5 cm from the surface is less than 5,000 Bq/kg in most farmland, even if the radiocesium concentration in the surface layer of about 5 cm exceeds 5,000 Bq/kg. The scraping thickness is set as 5 cm. But according to the sampling survey of the radiocesium concentration as a function of depth, there were cases in District D in which the concentration below 5 cm from the surface still exceeded 5,000 Bq/kg. Therefore, three scraping depths of 5 cm, 7 cm and 10 cm were applied in this test decontamination.
- The cases in which decontamination rates of 7 cm scraping were lower (higher contamination densities) than those of 5 cm scraping were considered to be due to localized conditions (a similar trend was noticed in the radiocesium concentration analysis in the layer, i.e. higher radiocesium concentrations when scraped by 7 cm than by 5 cm).
- The evaluation based on decontamination rates using surface contamination densities is generally considered appropriate for surface contamination. But such results were not always obtained in farmland. Contamination in farmland may not be surface contamination, but penetration contamination. In this case, the evaluation using dose equivalent rates would be more appropriate.
- Based on a proposal by the decontamination business operator, test measurements in a high dose area were conducted using a collimator and placing lead blocks on the ground, in order to shield from the surrounding radiation and preclude the influence of radiation sources other than those on the surface. The difference of air dose rates between the cases with shielding and without shielding is equivalent to the dose rate due to only gamma rays. This approach gave better (more accurate) values. But the difference was just a few percent and lead blocks are needed for measurement. In view of the workload required, ordinary measurements using a collimator of air dose rate at 1 cm from the surface is considered appropriate for measurements related to decontaminating farmland.
- Even with the scraping depth of 5 cm, the decontamination rate of more than 90% after plowing was obtained in the air dose rates as well as in the surface contamination densities.

[142] Topsoil scrapping and recovering machine

Table 6-32 Example results of scraping topsoil, bringing topsoil from another place, leveling unevenness, and implementing double plowing of rice fields

Work Schedule, Scraping depth		Air dose rate at 1 cm away from the surface (with shielding ,μSv/h)	Air dose rate at 1 m away from the surface (with shielding μSv/h)	Surface contamination density (with shielding cpm)	Decontamination rate of Air dose rate at 1 cm away from the surface (%))	Decontamination rate of Air dose rate at 1 m away from the surface (%)	Decontamination rate of surface contamination density (%)
Scraping 5 cm	Before scraping	8.1	–	–	–	–	–
	After scrapping	1.6	–	–	77		73
	After bringing topsoil from another place	5.6×10^{-1}	–	–	90	–	92
	After plowing	6.0×10^{-1}	–	–	89	–	91
Scraping 7cm	Before scraping	6.4	–	–	–	–	–
	After scraping	1.6	–	–	71	–	70
	After bringing topsoil from another place	6.0×10^{-1}	–	–	88		91
	After plowing	7.6×10^{-1}	–	–	87	–	88
Scraping 10 cm	Before scraping	8.1	–	–	–	–	–
	After scraping	2.6×10^{-1}	–	–	92	–	91
	After bringing topsoil from another place	2.0×10^{-1}	–	–	95		94
	After plowing	1.0×10^{-1}	–	–	96	–	95

※ The value shown in the table is the average of the value (s) measured at 3 locations.

※ The effect of decontamination depends on the various factors such as the material and the surface condition of decontamination target, their deterioration status and so on. The results shown above are the results which have been implemented in a tentative way for the specific target to be decontaminated. Therefore, it does not assure that the equivalent effect can be attained by the same decontamination method.

7. Conclusion

The Act on Special Measures Concerning Nuclear Emergency Preparedness of Japan (Law No.156, 1999) stipulated that the Nuclear Emergency Response Headquarters under the Cabinet Office was responsible for preventing the release of radioactive materials to the environment. But the concrete legal framework was not in place before the Fukushima Daiichi Nuclear Power Station (1FNPS) accident for emergency responses to contamination due to radioactive materials released to the public environment.

Under such circumstances, relevant government authorities including the MOE and local governments such as Fukushima Prefecture have been engaged in large scale decontamination works for diverse and vast areas including housing areas, public facilities, roads, farmland, forests near residential areas, etc. These works have been undertaken to ensure public safety for facilitating early return of residents to their homes and restoration of their daily lives. Such decontamination works are unprecedented worldwide and have been implemented with all possible ideas, accumulated experiences and knowledge in a trial-and-error approach.

The decontamination works continue. Key experience and knowledge of significance obtained to date are reviewed and summarized below.

(1) Fixing of legal, institutional and technical foundations

In August 2011, the Act on Special Measures Concerning the Handling of Radioactive Pollution by the Accident at the Nuclear Power Station caused by the Great East Japan Earthquake which occurred on March 11, 2011 (Law No. 110, 2011) (the "Act on Special Measures") was enacted in response to the 1FNPS accident. Thereafter, competent authorities including the MOE formulated relevant ministry ordinances, standards, guidelines, etc. as needed.

The MOE started the decontamination works under its direct jurisdiction based on the Common Specifications provisionally formulated in a trial-and-error approach, using the then existing rules and mechanisms practiced by the Ministry of Land, Infrastructure and Transport (MLIT), the Ministry of Agriculture, Forestry and Fisheries (MAFF), etc. In doing so, the MOE needed assistance from the experienced staff of MLIT and MAFF. The MOE lacked experienced personnel for public works under its direct jurisdiction. The MOE continued thereafter improving the Common Specifications step-by-step through trial-and-error in field experiences. Consequently, the whole framework of decontamination works has been specified to a certain degree, including concrete work implementation details. Prompt initiation of decontamination works, as needs emerged, has become possible, and quality of work has been pursued for improvement.

(2) Roles borne by the decontamination business operators in decontamination works

There were two big requirements to implement large scale decontamination works, besides technical competence for decontamination: one was the capacity to deliver the large amounts of equipment and human resources needed to the decontamination sites appropriately and in a timely manner, and the other was the project management capability to implement large scale decontamination works efficiently and effectively under tight time pressures.

Especially to note in the decontamination works after the Great East Japan Earthquake in 2011 was that the works had to be implemented under limited lifeline infrastructures. Under such circumstances, it was absolutely a must to involve credible local construction industry members for the decontamination works. They had experience and relevant technologies, which they accumulated by quickly restoring the area after such things as severe weather storms (e.g. typhoons and heavy snow). The decontamination business operators, whose key players were construction companies, have been engaged in the decontamination works while introducing non-conventional ideas by accumulating further experiences and knowledge.

Since the works which could be mechanized were limited in the decontamination works, large workforces were needed. But in nearby areas (especially Miyagi and Iwate Prefectures), large workforces were also in big demand for restoring the areas from the aftermaths of the earthquake and tsunami and for reconstruction. The decontamination business operators could manage to recruit a large number of workers with the cooperation of local construction companies, and the like. However, many of these workers were not experienced in site works of civil engineering and construction. These workers needed education, not only technical knowledge on decontamination or radiation protection, but also occupational safety and health for civil engineering and construction. Consequently, the decontamination business operators had to spend a large amount of time and do a lot of work to provide those many workers with education on decontamination and regular training of occupational safety and health.

Furthermore, the decontamination business operators often found it necessary to be very flexible in updating the work schedules, depending on the progress: for example, acquisition of agreement to land use for temporary material storage required before commencing decontamination work; or its progresses at each temporary storage site did not proceed as quickly as initially planned. The situation has been different from ordinary contracts for public construction works, in which the order is awarded after the land use conditions, and the like are fixed.

(3) Significance of decontamination model projects and existing technologies used in decontamination

Soon after the accident, several pilot projects of decontamination were implemented including "decontamination model projects" of the Cabinet Office. Such pilot decontamination projects did not necessarily show standard decontamination models, but they certainly brought good outcomes in identifying efficient and effective decontamination methods, and measures to ensure radiation workers' safety. It was a very meaningful step toward large scale decontamination works thereafter. The experiences and knowledge obtained from these pilot projects have also shown that the technologies having been accumulated in the construction industry or their improved technologies can be effectively used in decontamination works, too, and that improvement in working procedures and management is equally important in implementing decontamination works.

Another point to note is that accurate and efficient air-dose monitoring is needed in evaluating the appropriateness of the decontamination works and to this end various innovative monitoring technologies have been developed and applied, including mobile monitoring vehicles and drone monitoring helicopters.

Further to note is that such decontamination pilot projects have also worked, not only in accumulating technical knowledge, but in developing competent field workers with technical knowledge. They also could facilitate the understanding of local community residents about the decontamination works and their outcomes.

(4) Considerations in choosing decontamination methods and operation conditions

Decontamination methods to be applied, their operation conditions and the decontamination effects depend on various environmental conditions such as site situations, material properties or surface conditions of the objects subject to decontamination, or their aging variation with time. Therefore, the best decontamination methods or conditions are difficult to specify beforehand, even for a particular object to be decontaminated. For example, for decontaminating paved road surfaces, high-pressure water cleaning was effective to some extent in the early stage, but after some time, when radioactive cesium migrated from the ground surface deep into the materials, scraping of the paved road surface by shot-blasting became a practical and effective approach, instead of cleaning the surface.

It should be noted that the decontamination effect was not the only criterion for choosing the decontamination method and operation conditions. Construction workability as well as maintainability of target objects was also considered. Final selection of the decontamination methods and conditions were made only when the consent of local residents was obtained in the respective communities.

(5) Strengthening management for appropriate decontamination works

It was necessary to systematically fix documented work procedures, mechanisms, etc. for smooth operation of the decontamination works, in order to implement unprecedented large-scale decontamination works.

Nevertheless there were cases when the decontamination works not specified in the guidelines or in the Common Specifications became necessary, because the decontamination works had been implemented under the relevant knowledge being limited. In such cases, government supervisory personnel and the decontamination business operators jointly worked out the appropriate procedures to apply. Some of these procedures have been incorporated into the standard work procedures when it was deemed as being possible to generalize them. Thus, the PDCA cycle (Plan – Do – Check – Act) has been pursued for improvement.

In January 2013 it was reported that decontamination had been questionable in some cases. The report was about an incident which could have damaged public trust in the community. The MOE launched immediately the "Headquarters for Proper Decontamination Promotion" and formulated the "Appropriate Decontamination Program" consisting of three main pillars: Thorough responsibility for decontamination works by the decontamination business operators; Establishment of comprehensive management systems; and Strengthening of MOE organizational settings.

Based on this "Appropriate Decontamination n Program," emergency hotline telephone number "Decontamination Dial 110 (Hotline)" was set up at the MOE to receive information on questionable cases of decontamination. The information received was examined for confirming the facts and, as needed, attention of the decontamination business operators was drawn to the problems. Their responses to the information were disclosed on the MOE homepage.

(6) Communication with local residents

When implementing a big undertaking like the decontamination works, sufficient time is needed for preparation. But on the other hand, strong desires were expressed by the local residents to initiate decontamination works at the earliest possible time. It was very important, therefore, to establish mutual trust with the local residents through sincere communication, in implementing decontamination works, empathy with them in mind.

In the areas such as the Special Decontamination Areas, from where residents had evacuated, they could not witness the decontamination works by themselves. When planning decontamination work in such areas, opportunities were arranged for them to visit the site for their prior consent to the work or to confirm the decontamination works for themselves. For facilitating their prior consent, significant efforts were made to sincerely respond to them by hearing and evaluating their requests, and repeating explanatory responses to their concerns.

Since the decontamination works affect the buildings, houses and land directly, prior consent of their owners is legally required for the works. Therefore, drawings and photos were attached as appropriate to the document of consent in order to clearly stipulate the contents of agreement for both parties. The results of dose measurements before and after the decontamination works were also reported using drawings, and the like to relevant parties as appropriate including the owners.

(7) Collaboration with relevant organizations and information dissemination

It was absolutely indispensable, in implementing the decontamination works, to respond to all kinds of concerns and dissatisfactions of local residents about the decontamination methods and decontamination works, and concerns about safety of temporary storage sites. The MOE cooperated with Fukushima Prefecture and set up the "Decontamination Information Plaza," in order to disseminate relevant information on decontamination and radiation, and to set up an activity base for experts. The Decontamination Information Plaza has promoted communication with local communities by providing various exhibits and pamphlets, arranging workshops or opinion exchange meetings, dispatching registered experts to local governments or communities upon request, or responding to consultations from the local residents. The MOE has also made efforts to facilitate people's understanding through operating its websites and the Call Center, and information dissemination via mass media.

The MOE has kept close contacts with international organizations such as the IAEA in implementing the decontamination works and in parallel promoted information sharing with the international communities based on bilateral national cooperation agreements, and the like.

This report assembled comprehensively, with key attention to the decontamination works by the MOE, the basic policy of decontamination, its implementation framework, knowledge about managing the decontamination works based on the actual decontamination works experienced in the fields, and individual decontamination methods, conditions and effects thereof. The report was compiled by the Editorial Committee, which determined its structure, contents, items to survey, division of responsibilities, etc. Its members are listed below (The Mitsubishi Research Institute, Inc. served as the secretariat).

The report has assembled the experiences and knowledge concerning decontamination of radioactive materials in Japan, focusing on the activities of the MOE. But it is important to collect and preserve all relevant documents and data, not only those of MOE but those of relevant ministries, local governments, research institutes and other related institutions, in order to prepare for possible accidents in the future at nuclear facilities and also to contribute to the relevant research activities.

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